AFRL-HE-WP-TR-2006-0005

AIR FORCE RESEARCH LABORATORY

Aircrew Stabilization Improvement Task Windblast Tests with Tekscan Evaluation

Joseph A. Pellettiere
Thao Nguyen
Charles Nguyen

Air Force Research Laboratory

December 2005

Interim Report for the Period April 2000 to May 2004

Human Effectiveness Directorate
Biosciences and Protection Division
Biomechanics Branch
2800 Q Street, Bldg 824, Rm 206
Wright-Patterson AFB OH 45433-7947

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Please do not request copies of this report from the Air Force Research Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies registered with the Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Center
8725 John J. Kingman Rd., Ste 0944
Ft. Belvoir VA 22060-6218

TECHNICAL REVIEW AND APPROVAL

AFRL-HE-WP-TR-2006-0005

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE DIRECTOR

//SIGNED//

MARK M. HOFFMAN
Deputy Chief, Biosciences and Protection Division
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MMM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From – To)
DECEMBER 2005	Interim Report	APRIL 2000 – MAY 2004

4. TITLE AND SUBTITLE

Aircrew Stabilization Improvement Task Windblast Tests with Tekscan Evaluation

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
62202F

6. AUTHOR(S)

Joseph Pellettiere (AFRL/HEPA); Thao Nguyen (AFRL/SNRP); Charles Nguyen (AFRL/HEPA)

5d. PROJECT NUMBER
7184

5e. TASK NUMBER
02

5f. WORKUNIT NUMBER
05

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Materiel Command
Air Force Research Laboratory, Human Effectiveness Directorate
Biosciences & Protection Division
Biomechanics Branch
Wright-Patterson AFB OH 45433-7947

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-HE-WP-TR-2006-0005

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR / MONITOR' S ACRONYM
AFRL/HEPA

11. SPONSOR/MONITOR'S REPO RT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The windblast experienced by a pilot during aircraft ejection can exert considerable forces to the pilot's upper torso. The T-38 Aircrew Stabilization Improvement Task (ASIT), managed by the 311 Human Systems Wing, developed windblast deflector concepts to help mitigate these potentially injurious effects. The Air Force Research Laboratory, Biomechanics Branch (AFRL/HEPA) provided technical guidance and test support to the ASIT effort during the testing of these deflector concepts, as well as an evaluation of the Tekscan pressure measurement system to record pressures on the chest in the windblast environment.

15. SUBJECT TERMS

Windblast Testing, Inflatable Restraint, Pressure Measurement

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON:
a. REPORT	b. ABSTRACT	c. THIS PAGE			Joseph A. Pellettiere
U	U	U	SAR	157	19b. TELEPHONE NUMBER *(Include area code)* 937-255-1150

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39-18

THIS PAGE IS INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

PREFACE V
INTRODUCTION AND OVERVIEW 1
TEST DESCRIPTION 4
DATA COLLECTION AND PROCESSING 5
TEST RESULTS 6
CONCLUSION 9
APPENDIX A - TEST CONDITION SUMMARY 11
APPENDIX B - CREW EQUIPMENT 15
APPENDIX C - EJECTION SEAT COORDINATE SYSTEM 17
APPENDIX D - TEST SUMMARY 19
APPENDIX E - PROCESSED DATA PLOTS 23
APPENDIX F - NECK LOAD SUMMARY 130
APPENDIX G - CHANNEL DEFINITION/CALIBRATION 131
APPENDIX H - TEKSCAN TESTS 135
APPENDIX I - TEKSCAN AND KULITE SENSOR ARRAY DATA PLOTS . 139

LIST OF FIGURES

Figure 1. Torso Pressure Rake 1
Figure 2. Truncated Cone 3
Figure 3. Mass and Sail 3
Figure 4. Post 3
Figure 5. Pillar 3
Figure 6. Neck Tension Comparison at 575 KEAS 8
Figure D-1. Hybrid III with Pillar 21
Figure D-2. Hybrid III with Post 21
Figure H-1. Kulite Sensor 136
Figure H-2. Tekscan Sensor 137
Figure H-3. Manikin with Sensor Mat 137

LIST OF TABLES

Table 1. Test Matrix 2
Table 2. Peak Pressure (PSI) Recorded at each Kulite Sensor at 375 KEAS 6
Table 3. Peak Pressure (PSI) Recorded at each Kulite Sensor at 450 KEAS 7

PREFACE

The research described in this report was conducted by personnel of the Biodynamics and Acceleration Branch, Biodynamics and Protection Division, Human Effectiveness Directorate of the Air Force Research Laboratory (AFRL/HEPA) and supported by Veridian Engineering from 24 April 2000 to 28 April 2000. The testing was conducted at the Dayton T. Brown test facilities in Bohemia, NY.

Dr. Joseph A. Pellettiere of AFRL/HEPA served as the principal investigator and project manager with Mr. Thao Nguyen and Capt. Charles Nguyen as the associate investigators. This project was funded by the 311 HSW as part of the Aircrew Seat Improvement Task (ASIT).

THIS PAGE IS INTENTIONALLY LEFT BLANK

INTRODUCTION AND OVERVIEW

The windblast experienced by the pilot as the canopy is jettisoned and he enters the airflow can result in the transfer of significant forces and moments to the neck and chest. The T-38 Aircrew Stabilization Improvement Task (ASIT) Test Program was conducted to validate the feasibility of improving crewmember safety through the use of a windblast deflector. The target areas were a reduction of neck and chest loading during high-speed ejection by diverging the airflow before it reaches the pilot. Airflow divergence was produced by deploying a windblast deflector at the front of the ejection seat at the beginning of the windblast event.

AFRL/HEPA provided manikins, instrumentation, and data acquisition. AFRL/HEPA collected the data for further presentation and analysis by HSW/YACL. The data contained herein is the result of the Aircrew Stabilization Improvement Task (ASIT), contract # N00421-99-C-1400, concepts. ASIT is a program being managed by HSW/YACL. The concepts presented, configurations tested, and development program are solely the work of HSW/YACL and the contractor, BF Goodrich's Universal Propulsion Company (UPCO). AFRL/HEPA provided the test support documented in this report. As such, this report contains no recommendations or conclusions on the performance or feasibility of any of the concepts presented. Additionally, any testing conducted by AFRL/HEPA should not be construed as support or recommendation for any of the concepts, applicability of the system for use in an ejection environment or results of this program.

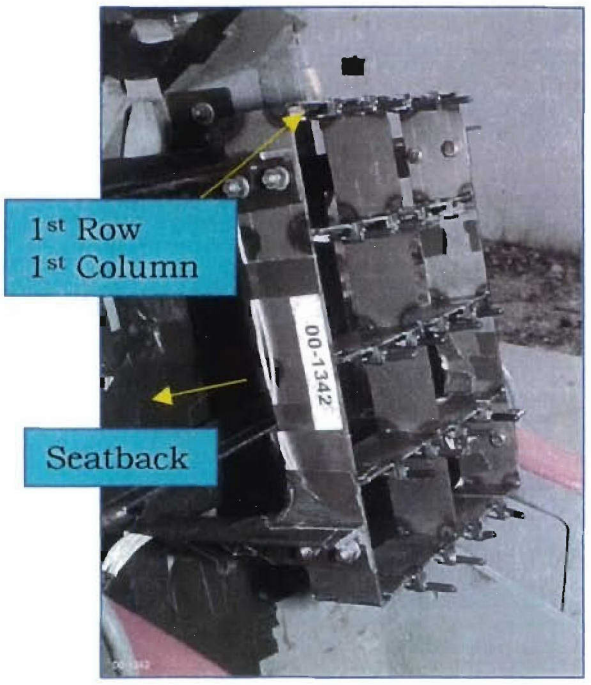


Figure 1. Torso Pressure Rake

This test program initially aimed at using the Tekscan pressure mat system as a measuring device to record the airflow pressure exerted on the manikin's upper body during windblast exposure. The pressure mat could be easily affixed to the manikin torso skin under the flight suit. If successful, this testing method could be used to estimate chest compression loads and airflow distribution on the manikin during sled ejection tests, thus providing a more complete tool for injury risk assessment. As an alternate method, a torso rake with pressure sensors (Figure 1) could be mounted in the seat in place of the manikin to measure the pressure from the incoming flow.

This data report contains the results of twelve (12) windblast tests conducted at airspeeds of 375, 450, and 575 Knots Equivalent Airspeed (KEAS). The windblast deflector was pre-deployed prior to each test. Table 1 provides the test matrix for this windblast test program and Figures 2-5 show the test

articles. The data collected were used as part of a comparative analysis to identify the configuration that produced the lowest chest load and neck lift during windblast exposure.

Personnel from Dayton T. Brown were responsible for seat system setup, operation of the windblast facility, and safe conduct of the test. The Biodynamics and Acceleration Branch of the Air Force Research Laboratory provided manikin support and instrumentation, data collection and processing, and data summary. The AFRL engineers on site for this test were Mr. Thao Nguyen and Capt. Charles Nguyen (AFRL/HEPA).

Table 1. Test Matrix

Test No.	Test Item	Airspeed (KEAS)	Testing Device	Testing Objectives
1	Baseline	350	Manikin/Tekscan	Neck Loads & Chest Pressure
1A	Baseline	350	Manikin/Tekscan	Neck Loads & Chest Pressure
2	Baseline	375	Torso Rake	Chest Pressure
3	Truncated Cone	375	Torso Rake	Chest Pressure
4	Mass and Sail	375	Torso Rake	Chest Pressure
5	Post	375	Torso Rake	Chest Pressure
6	Pillar	375	Torso Rake	Chest Pressure
7	Pillar	450	Torso Rake	Chest Pressure
8	Post	450	Torso Rake	Chest Pressure
9	Pillar	575	Manikin	Neck Loads
10	Post	575	Manikin	Neck Loads
11	Baseline	575	Manikin	Neck Loads

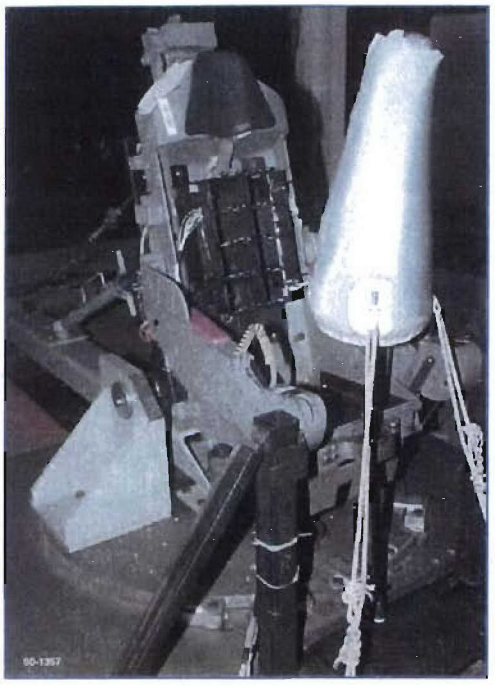


Figure 2. Truncated Cone

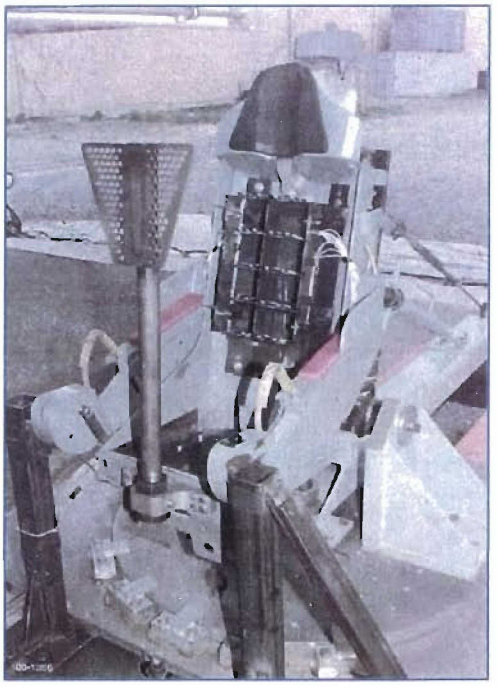


Figure 3. Mass and Sail

Figure 4. Post

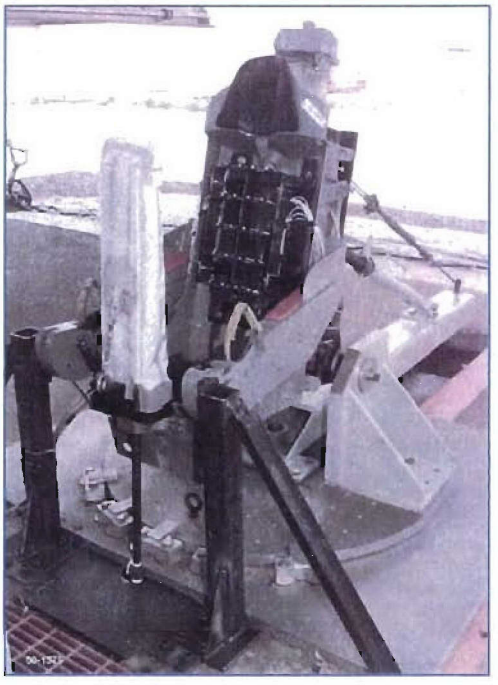


Figure 5. Pillar

TEST DESCRIPTION

The purpose of the tests was to evaluate the windblast deflector concepts designed by UPCO under windblast exposure.

The tests were performed at 375, 450, and 575 Knots Equivalent Airspeed (KEAS). At first, the Tekscan pressure mat system was used to record the airflow pressure exerted on the manikin's upper body during windblast exposure. However, after two baseline tests at 350 KEAS, the Tekscan system showed some inconsistencies in recording pressure data. As an alternate method, the torso rake was mounted in the seat to measure the pressure from the incoming flow. The test was conducted with either a 50th percentile Hybrid III manikin, which was assembled with a modified Hybrid II head, or with the torso pressure rake depending on the testing objectives (Table 1- Test Matrix). Four windblast deflectors, designated Truncated Cone, Mass and Sail, Post, and Pillar, were tested with the T-38 ejection seat. Of these four configurations, the Truncated Cone and the Pillar are inflatable. Neck loads and torso pressures were recorded and compared to a baseline configuration without a windblast deflector.

DATA COLLECTION AND PROCESSING

During these windblast tests, the data were collected at 5,000 Hz and used the Data Acquisition System (DAS) low-pass filter of 2,000 Hz.

After the data had been collected and downloaded to the computer, the data were viewed through the DAS software to provide a quick look. The data were extracted and converted to ASCII format using the DAS software. The extracted data starting point was a roundup of a half-second prior to the initial response of the main rake pressure, which is collected through the pressure rake mounted in front of the windblast nozzle. The time duration of the data was 2.00 seconds. The data were zeroed using the data collected immediately prior to the DAS triggering. The data were decimated to a 100-Hertz sample rate.

Peak pressures at each sensor location were compared for all tests of the same airspeed. The total chest compression load can be estimated by averaging the peak pressure data of all sensors, then multiplying for the torso rake area. To conduct a comparative analysis of the neck loads, the peak measurements were adjusted using the Pressure Correction Factor (PCF) for each test (Appendix A.) To compare the findings based on the aerodynamic loads, the measured pressure at the windblast nozzle was used to compute the PCF. The PCF is the ratio of the dynamic pressure, corresponding to the planned test speed at the windblast nozzle, divided by the actual output pressure measured at the windblast nozzle. This assumes that the dynamic pressure is linear within ±10 KEAS.

TEST RESULTS

All DAS data channels were recorded and downloaded successfully. The Tekscan pressure mat did not properly record the pressure data in tests 1 and 1A. Therefore, in order to measure aerodynamic loads acting on the manikin torso behind a windblast deflector, the test manikin had to be removed from the seat and replaced with the torso rake. Five tests were conducted at 375 KEAS. Of the four deflector configurations, the Post and the Pillar diverted the incoming airflow most effectively. Table 2 summarizes the results from the data collected with the torso rake, whose first row, first column is at the top left corner (Figure 1).

Table 2. Peak Pressure (PSI) Recorded at Each Kulite Sensors at 375 KEAS

Sensor (Row/ Column)	Baseline	Truncated Cone (Inflatable)	Pillar (Inflatable)	Mass and Sail	Post
1, 1	2.32	2.40	0.33	0.57	0.35
1, 2	2.38	2.88	0.19	0.42	0.35
1, 3	2.33	2.73	0.31	0.36	0.35
1, 4	2.59	2.86	0.34	0.66	0.38
2, 1	Bad Data	Bad Data	0.48	1.91	0.57
2, 2	2.62	2.43	0.36	1.07	0.40
2, 3	3.24	2.93	0.36	1.34	0.45
2, 4	3.33	2.94	0.36	1.62	0.46
3, 1	2.26	1.25	0.24	1.33	0.36
3, 2	2.59	1.73	0.32	1.43	0.33
3, 3	3.05	2.11	0.37	1.96	0.55
3, 4	3.03	2.08	0.37	2.08	0.56
4, 1	2.78	1.44	2.25	3.18	0.77
4, 2	2.50	1.49	0.68	1.66	0.33
4, 3	3.15	2.14	1.19	2.59	0.49
4, 4	3.31	2.30	1.70	2.73	0.56
5, 1	1.88	1.19	0.34	1.16	0.38
5, 2	2.69	1.88	1.26	1.85	1.03
5, 3	3.19	2.00	1.28	2.55	1.05
5, 4	3.14	2.25	2.19	2.74	1.49

The Post and the Pillar were selected for further testing at 450 KEAS. The Post performance was better than the Pillar by producing lower pressure in the lower torso region (Table 3, Rows 4 and 5) and not creating negative pressure in the upper torso region (Appendix E, Tests 6 and 7).

Table 3. Peak Pressure (PSI) Recorded at Each Kulite Sensor at 450 KEAS

Sensor (Row/ Column)	Pillar (Inflatable)	Post
1, 1	0.36	0.38
1, 2	0.37	0.58
1, 3	0.36	0.38
1, 4	0.38	0.41
2, 1	0.51	0.63
2, 2	0.39	0.50
2, 3	0.41	0.58
2, 4	0.40	0.53
3, 1	0.35	0.48
3, 2	0.35	0.39
3, 3	0.41	0.60
3, 4	0.41	0.71
4, 1	2.31	0.71
4, 2	1.11	0.72
4, 3	1.57	0.68
4, 4	2.19	0.69
5, 1	0.84	0.98
5, 2	1.71	1.34
5, 3	1.94	1.36
5, 4	3.04	2.00

Neck tension was recorded and compared to a baseline configuration with no windblast deflector. Peak neck tension values are presented in Appendix F. The Post produced the lowest measured neck loads (Figure 6).

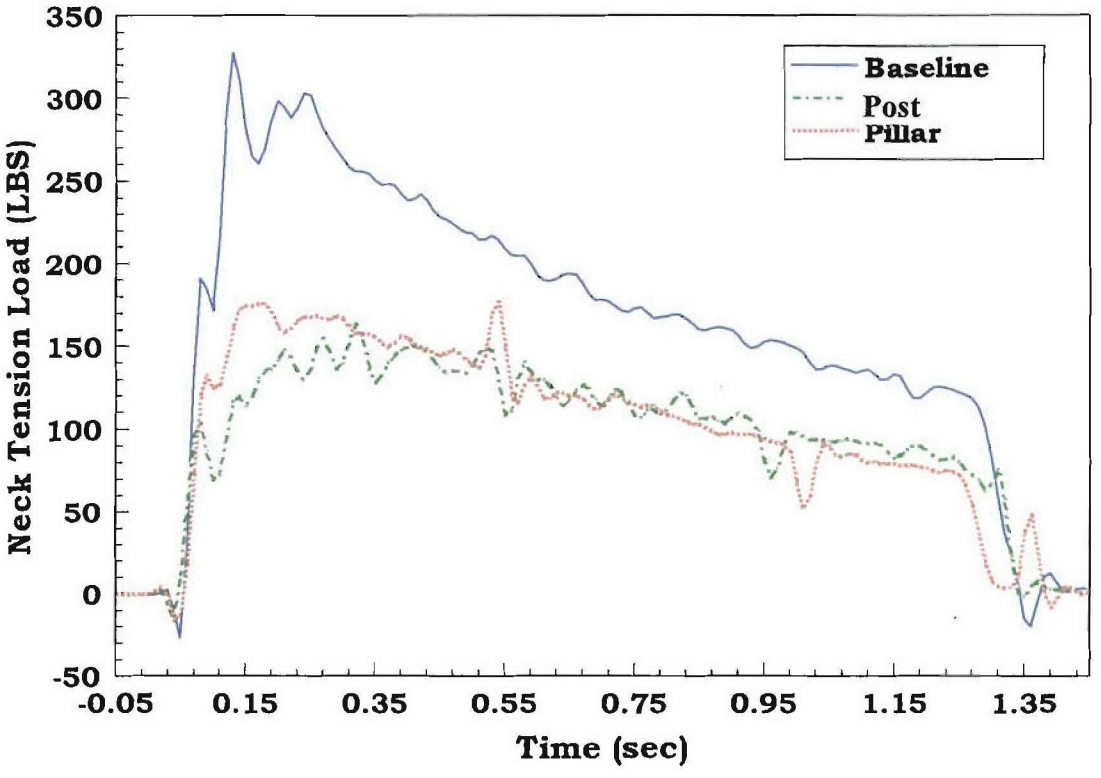


Figure 6. Neck Tension Comparison at 575 KEAS

CONCLUSION

All tests achieved sufficient airspeed to produce the desired aerodynamic forces. A leakage was found with the Truncated Cone inflatable deflector during testing. Breakage of the chin-nape strap in the test with the Post at 575 KEAS resulted in manikin neck loads that were higher than expected. Despite this problem, the Post performance was superior compared to other tested configurations. The processed data indicated that the Pillar produced the second-best neck and chest loading. However, these data also showed that negative pressures were present in the torso region for this configuration (Appendix E, Tests 6 and 7). Further study is required to eliminate this undesirable effect since the reacting loads exerted on the crewmember by the seat harness will likely be increased.

This page is intentionally left blank.

APPENDIX A

TEST CONDITION SUMMARY

Test Designation	WD1	WD1A	WD2	WD3	WD4	WD5	WD6	WD7
Date	26 Apr 00	26 Apr 00	26 Apr 00	26Apr 00	27 Apr 00	27 Apr 00	27 Apr 00	27 Apr 00
Restraint	Baseline	Baseline	Baseline	Truncated Cone	Mass & Sail	Post	Pillar	Pillar
Testing Device	Hybrid III	Hybrid III	Torso Rake	Torso Rake	Torso Rake	Torso Rake	Torso Rake	Torso Rake
Seat Back Angle	13°	13°	13°	13°	13°	13°	13°	13°
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Test Item (KEAS)	350	350	375	375	375	375	375	450
Main Rake Airspeed (KEAS)	358	368	369	379	365	374	377	446
Pressure Correction Factor	0.953572	0.897127	1.035238	0.980287	1.059525	1.0071	0.990615	1.018917

Test Designation	WD8	WD9	WD10	WD11
Date	27 Apr 00	28 Apr 00	28 Apr 00	28 Apr 00
Restraint	Post	Pillar	Post	Baseline
Testing Device	Torso Rake	Hybrid III	Hybrid III	Hybrid III
Seat Back Angle	13°	13°	13°	13°
Geometric Altitude (ft)	Sea Level	Sea Level	Sea Level	Sea Level
Target Airspeed at Test Item (KEAS)	450	575	575	575
Main Rake Airspeed (KEAS)	449	585	574	573
Pressure Correction Factor	1.007232	0.960037	1.003162	1.007428

This page is intentionally left blank.

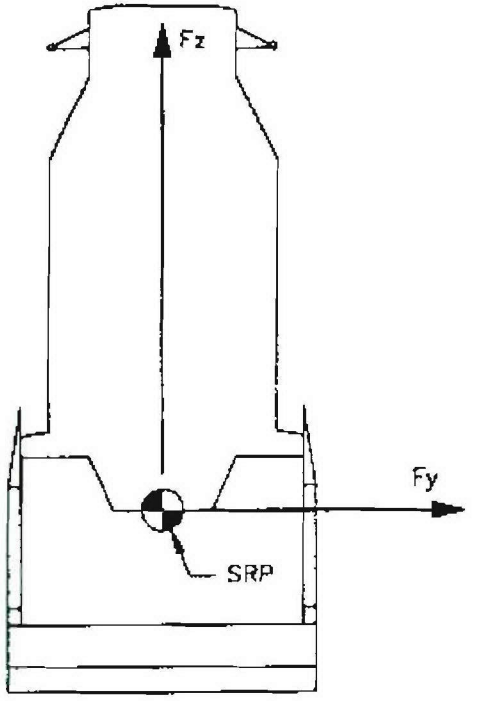
APPENDIX B

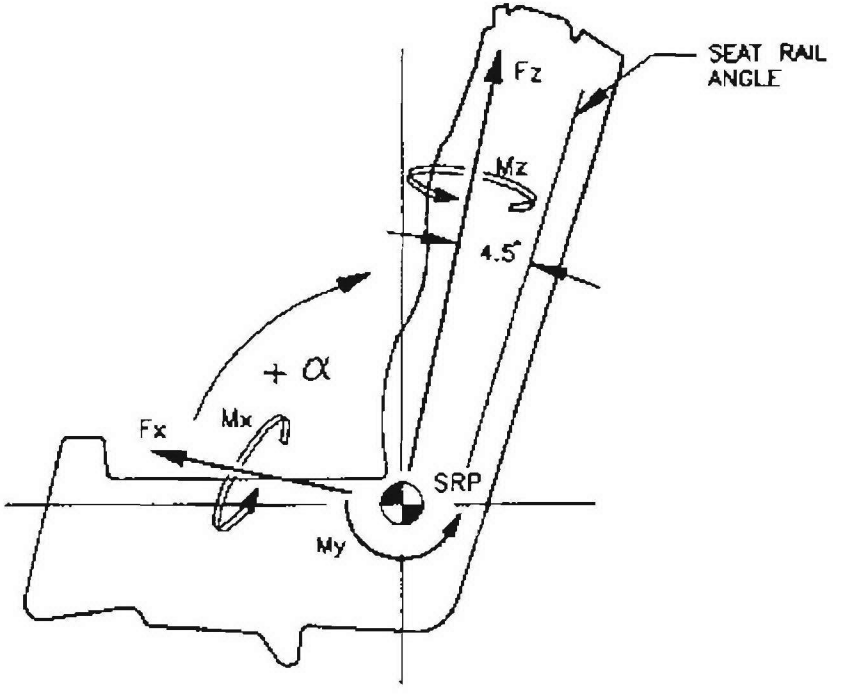
CREW EQUIPMENT

	Hybrid III Manikin	
Equipment	Model Number	Size
Flight Gloves	GS/FRP-2	11
Boots	FWU-8/P	11 EE
Flight Coverall	CWU-27/P	44 L
Helmet	HGU-55/P	Large
Oxygen Mask	MBU-20/P	L/W
Torso Harness	PCU-15/P	
Survival Vest	SRU-21/P	Medium
Anti-G Suit Garment	CSU-13B/P	Large Reg

APPENDIX C

EJECTION SEAT COORDINATE SYSTEM


Fz
Fy
SRP


SEAT RAIL
ANGLE
Fz
Mz
4.5°
+ α
Fx
Mx
SRP
My

APPENDIX D

TEST SUMMARY

The following are summaries for each of the twelve tests. Note that for Tests 1, 1A, 9, 10, and 11, the manikin was set up so that the helmet was rested on the seat headrest. The direction of the peak neck loads in the x-axis reported below is from front to aft. Tests 2-8 were conducted with the torso rake and no manikin.

1. Test #1: **T-38 seat with Hybrid III manikin at 350 KEAS.** The peak neck loads were 34 pounds in the x-axis, 22 pounds in the y-axis, and 123 pounds in the +z-axis. Connectivity problems with the Tekscan pressure mat connector resulted in no torso pressure data being recorded.

1A. Test #1A: **Repeat of Test #1.** The peak neck loads were 25 pounds in the x-axis, 18 pounds in the y-axis, and 153 pounds in the +z-axis. The Tekscan system again had problem to properly record the pressure data. As an alternate method, the torso rake was mounted in the seat in place of the manikin to measure the pressure from the incoming flow.

2. Test #2: **T-38 empty seat at 375 KEAS.** The torso rake was used to collect pressure data. This is a baseline test.

3. Test #3: **T-38 with the Truncated Cone at 375 KEAS.** The torso rake was used to collect pressure data. The performance of this inflatable windblast deflector was slightly better than the baseline.

4. Test #4**: T-38 with the Mass and Sail at 375 KEAS.** This concept was slightly better than the Truncated Cone.

5. Test #5: **T-38 with the Post at 375 KEAS.** The Post performance was superior compared to other tested configurations.

6. Test #6: **T-38 with the Pillar at 375 KEAS.** The processed data showed that the Pillar produced the second best chest loading. This inflatable concept was selected for further testing.

7. Test #7: **Repeat of Test #6 at 450 KEAS.** The Pillar showed a significant reduction of chest loading.

8. Test #8: **Repeat of Test #5 at 450 KEAS.** The Post performance again was slightly better than the Pillar.

9. Test #9: **T-38 seat with Hybrid III manikin and the Pillar at 575 KEAS (Figure D-1).** The peak neck loads were 14 pounds in the x-axis, 25 pounds in the y-axis, and 170 pounds in the +z-axis.

Figure D-1. Hybrid III with Pillar

Figure D-2. Hybrid III with Post

10. Test #10: **T-38 seat with Hybrid III manikin and the Post at 575 KEAS (Figure D-2).** The peak neck loads were 10 pounds in the x-axis, 22 pounds in the y-axis, and 165 pounds in the +z-axis. Breakage of the chin-nape strap resulted in higher neck tension load.

11. Test #11: **T-38 seat with Hybrid III manikin at 575 KEAS.** The peak neck loads were 17 pounds in the x-axis, 44 pounds in the y-axis, and 330 pounds in the +z-axis. This is a baseline test.

This page is intentionally left blank.

APPENDIX E

PROCESSED DATA PLOTS

WD1, 350 KEAS

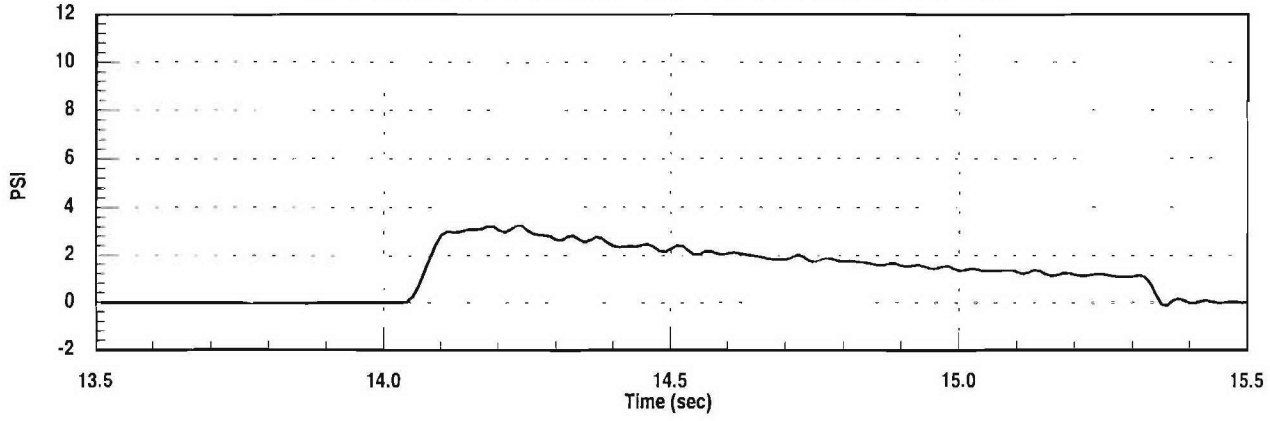
T-38 Baseline / Hybrid III

Processed Data

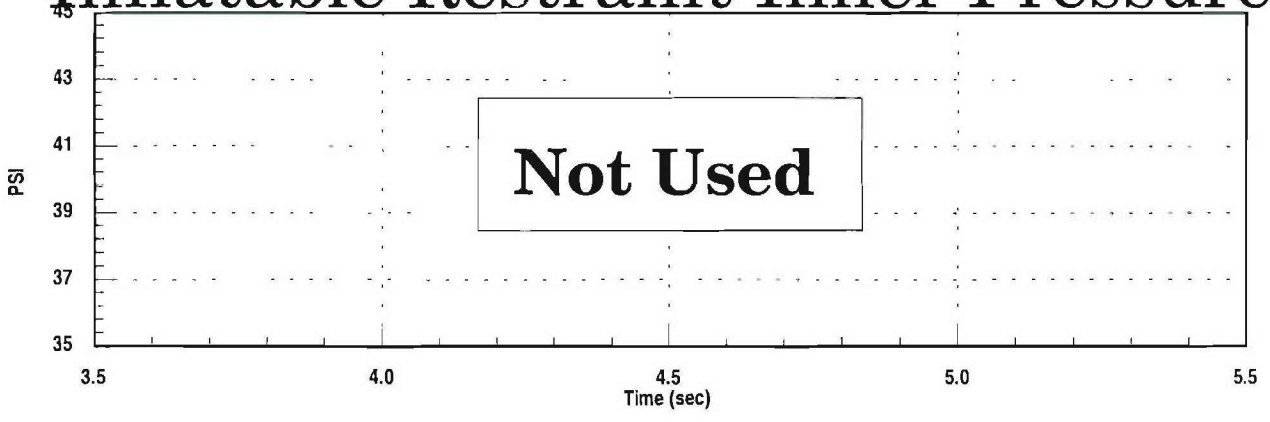
Main Rake Pressure E-2
Neck Forces E-3
Neck Moments E-4

WD1, 350 KEAS

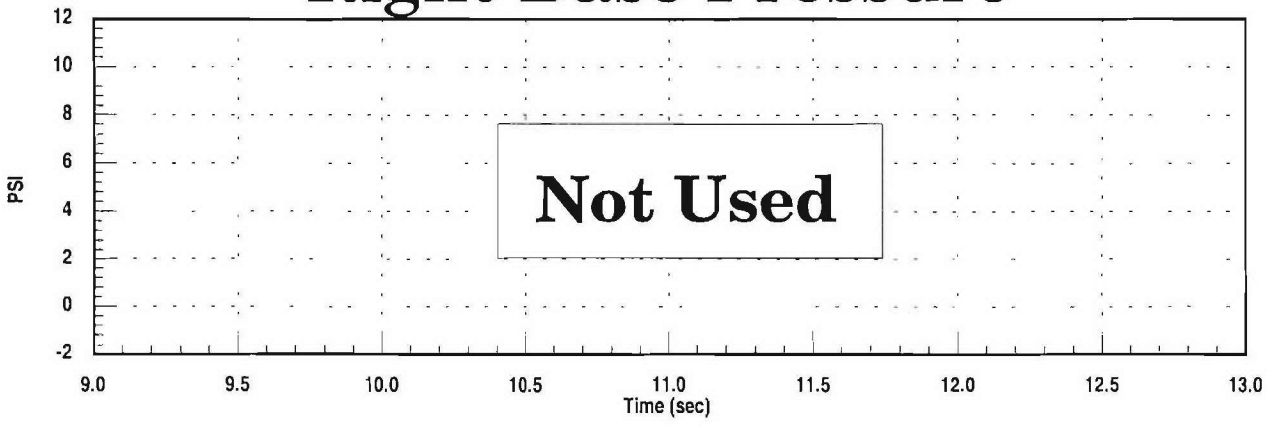
T-38 Baseline / Hybrid III
Main Rake Pressure



Inflatable Restraint Inner Pressure



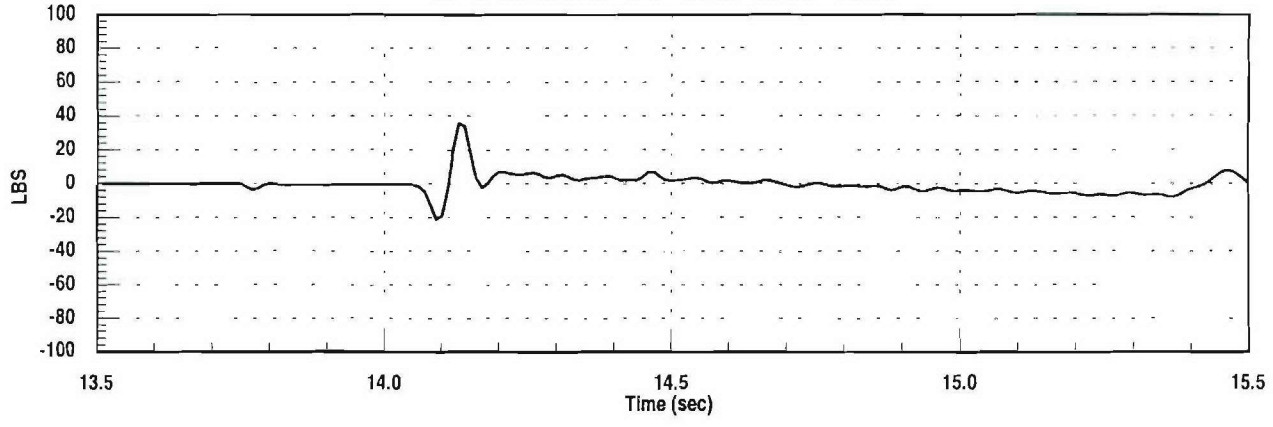
Right Base Pressure



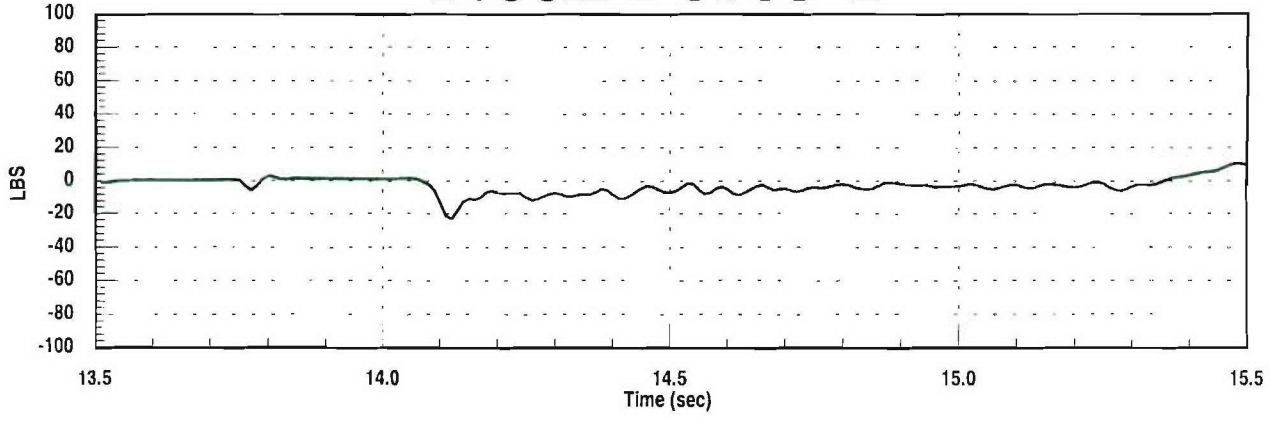
WD1, 350 KEAS

T-38 Baseline / Hybrid III

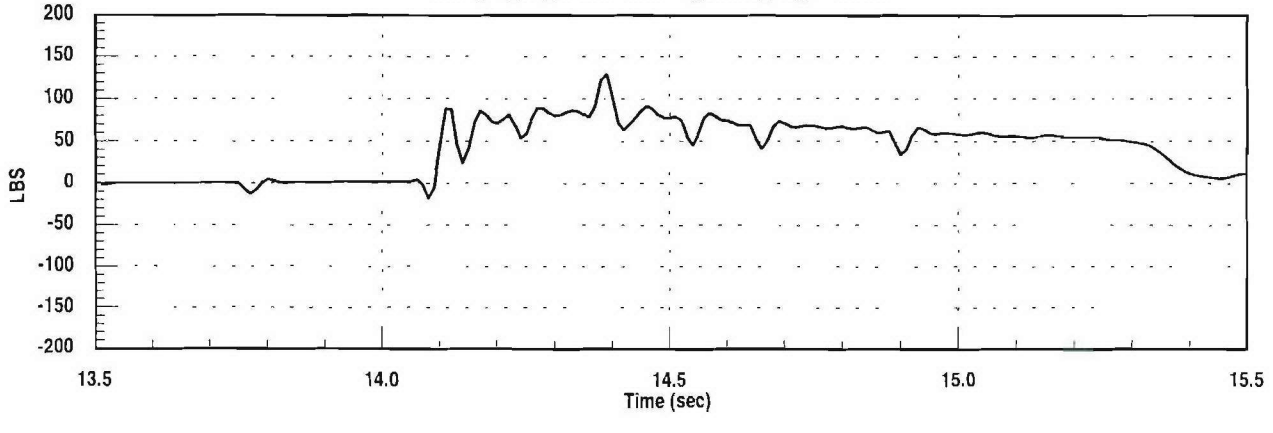
Neck Force X



Neck Force Y



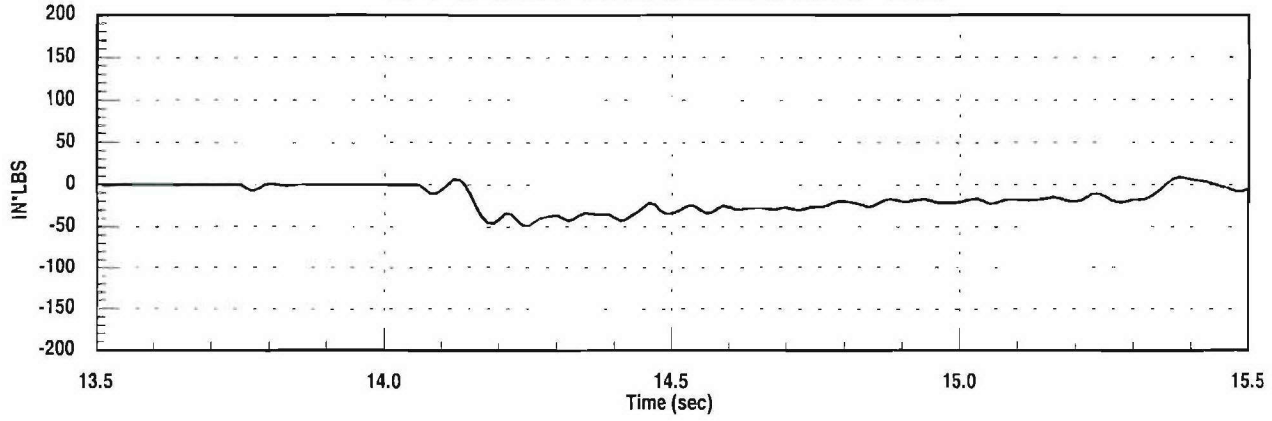
Neck Force Z



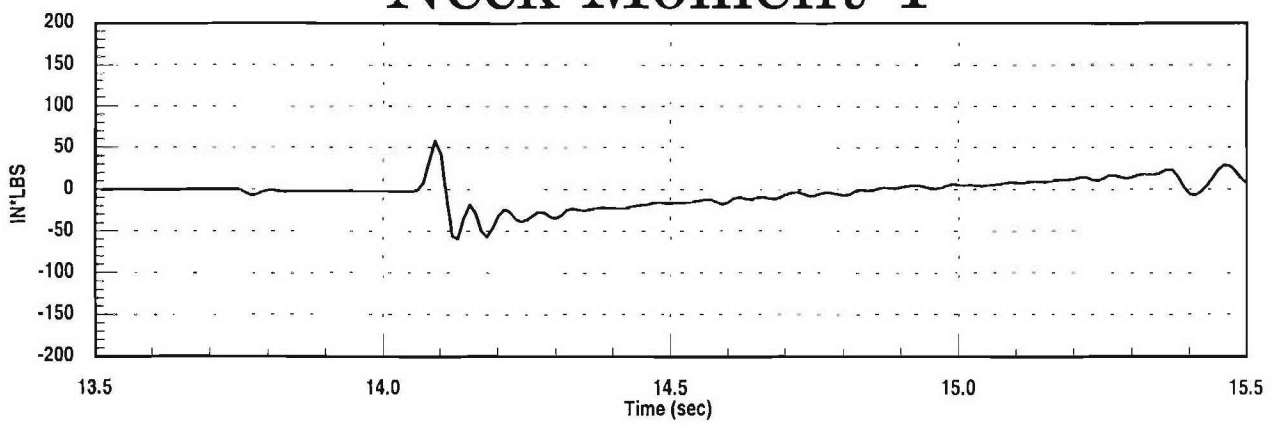
WD1, 350 KEAS

T-38 Baseline / Hybrid III

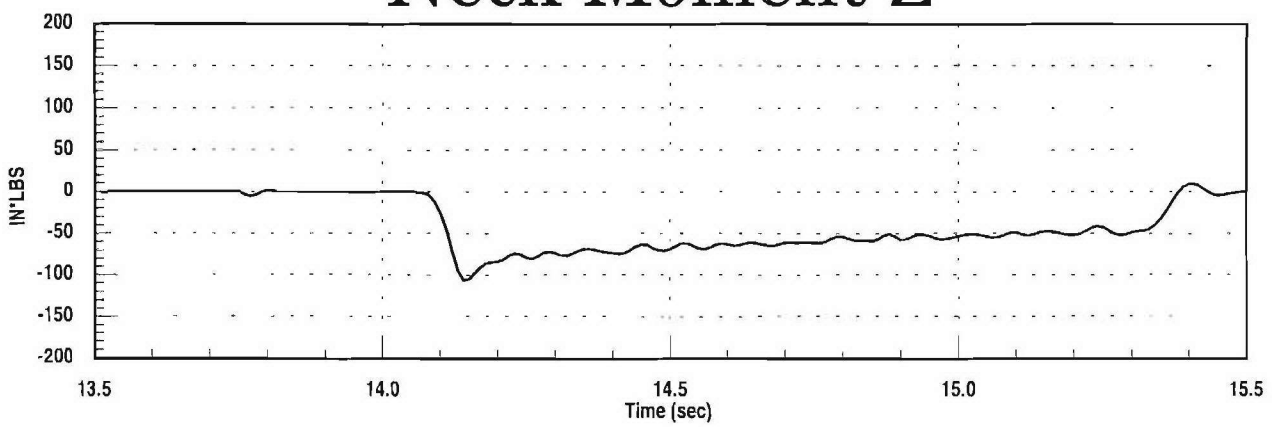
Neck Moment X



Neck Moment Y



Neck Moment Z



WD1A, 350 KEAS

T-38 Baseline / Hybrid III

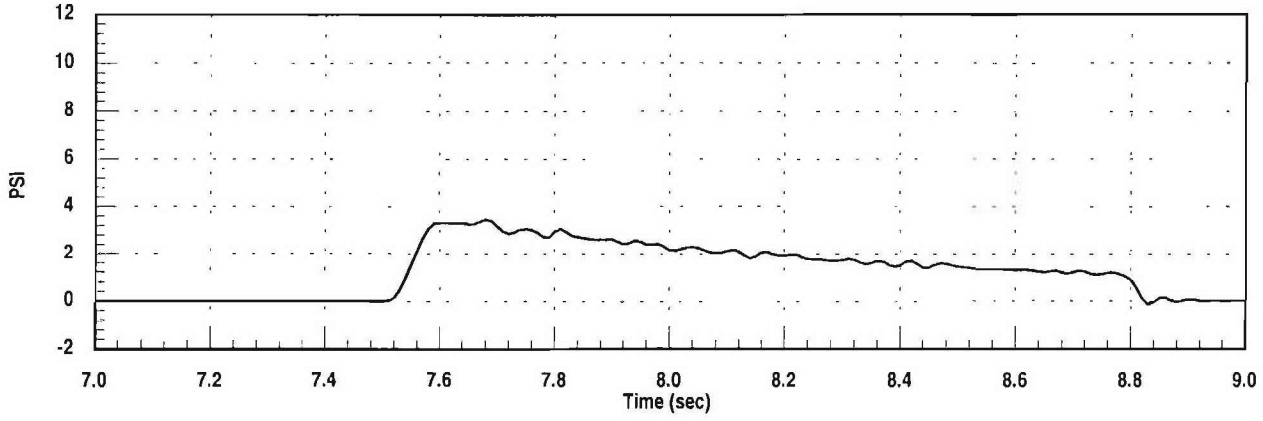
Processed Data

Main Rake Pressure	E-6
Neck Forces	E-7
Neck Moments	E-8

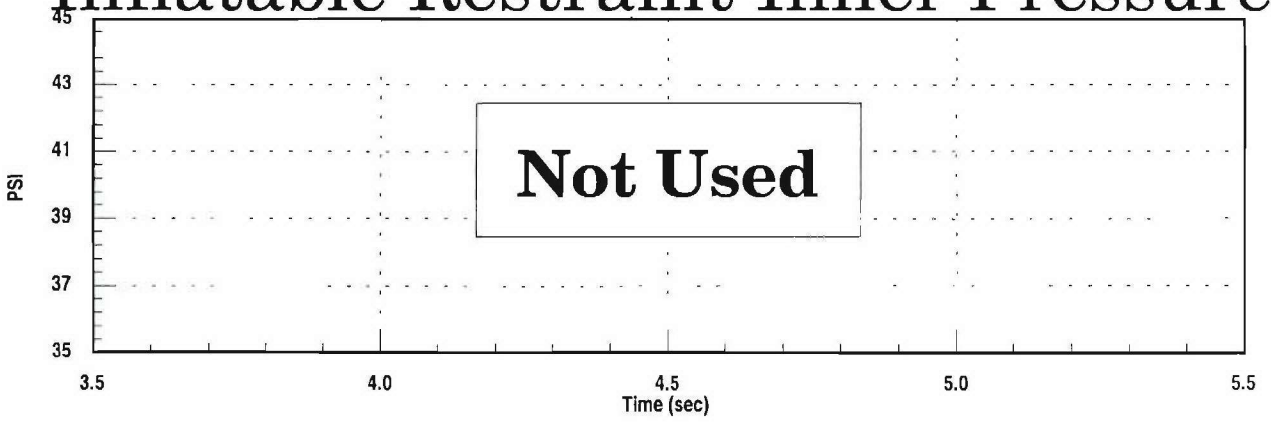
WD1A, 350 KEAS

T-38 Baseline / Hybrid III

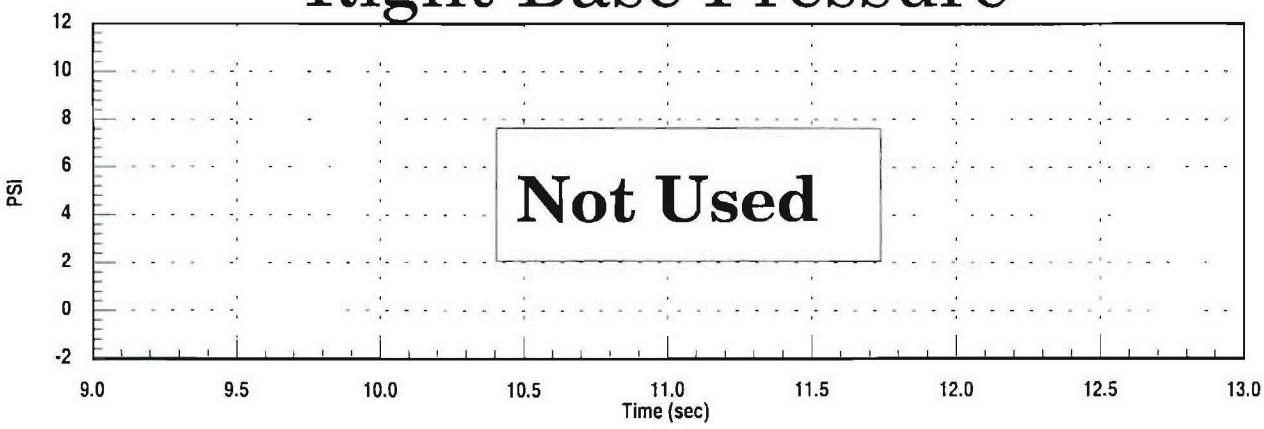
Main Rake Pressure



Inflatable Restraint Inner Pressure



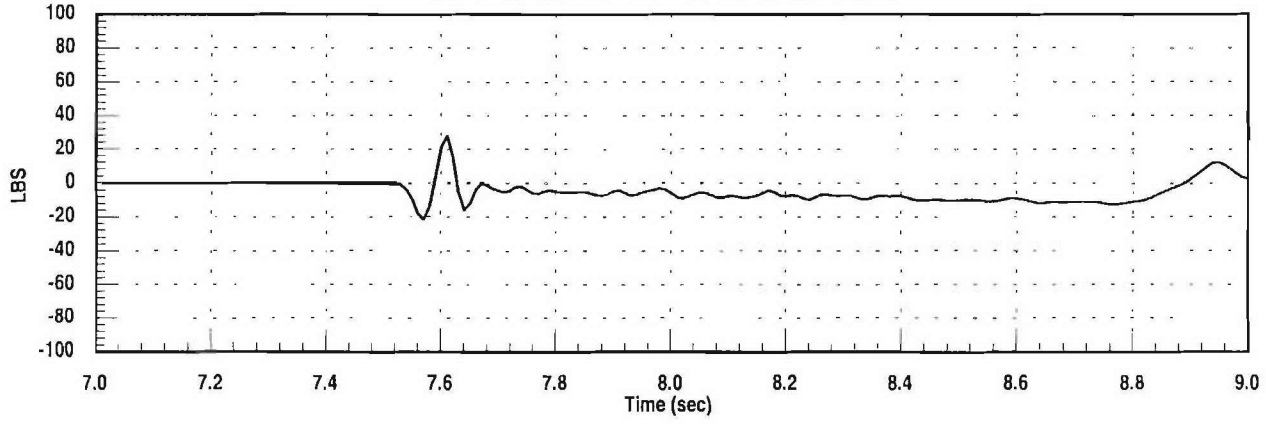
Right Base Pressure



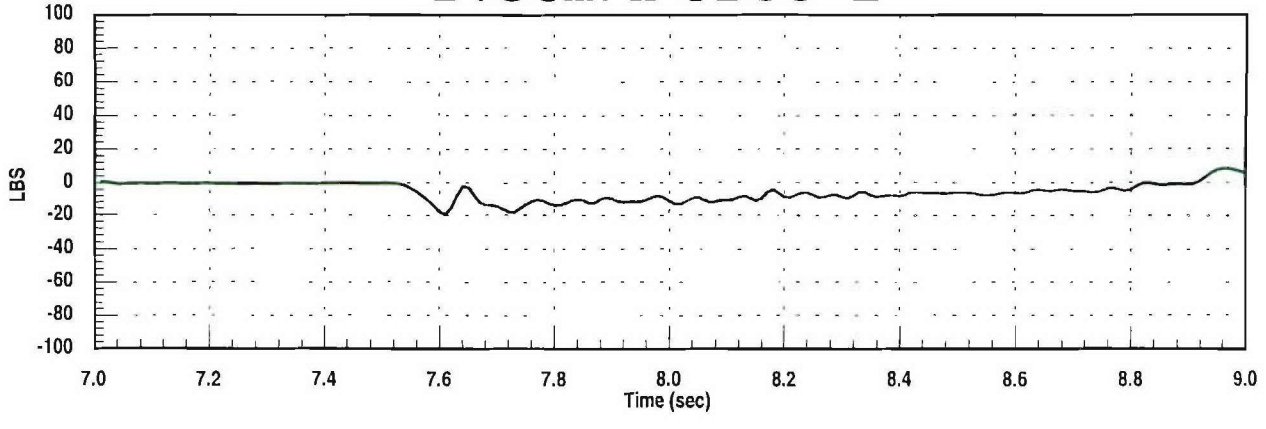
WD1A, 350 KEAS

T-38 Baseline / Hybrid III

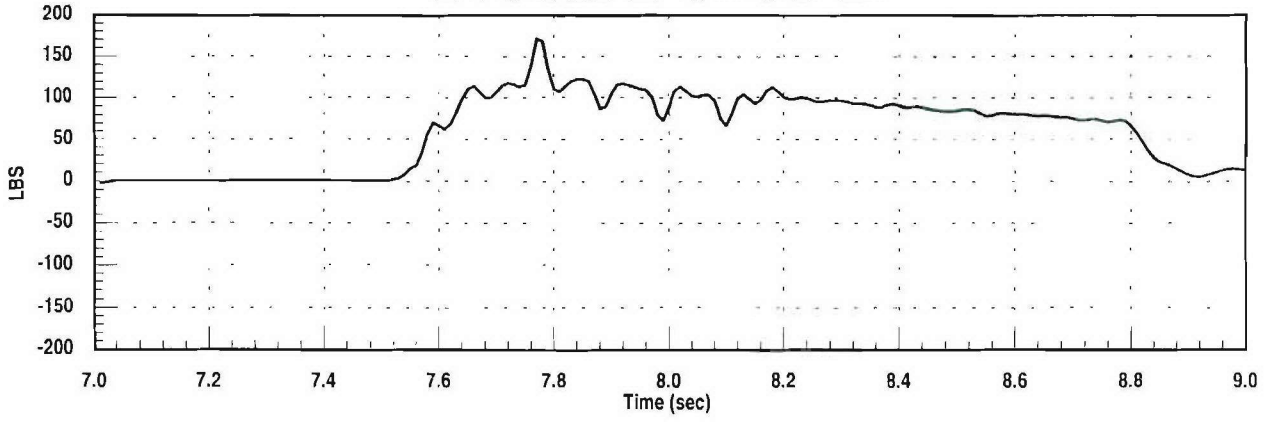
Neck Force X



Neck Force Y



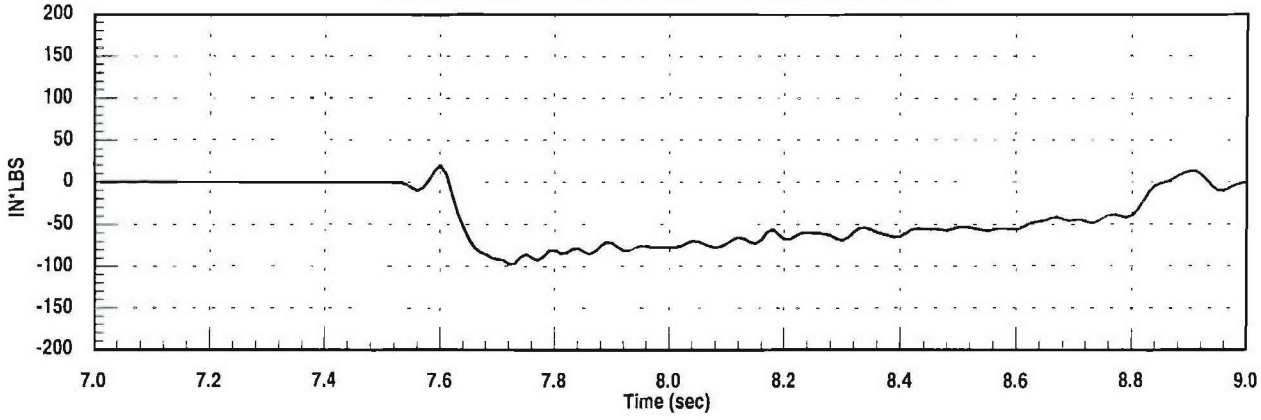
Neck Force Z



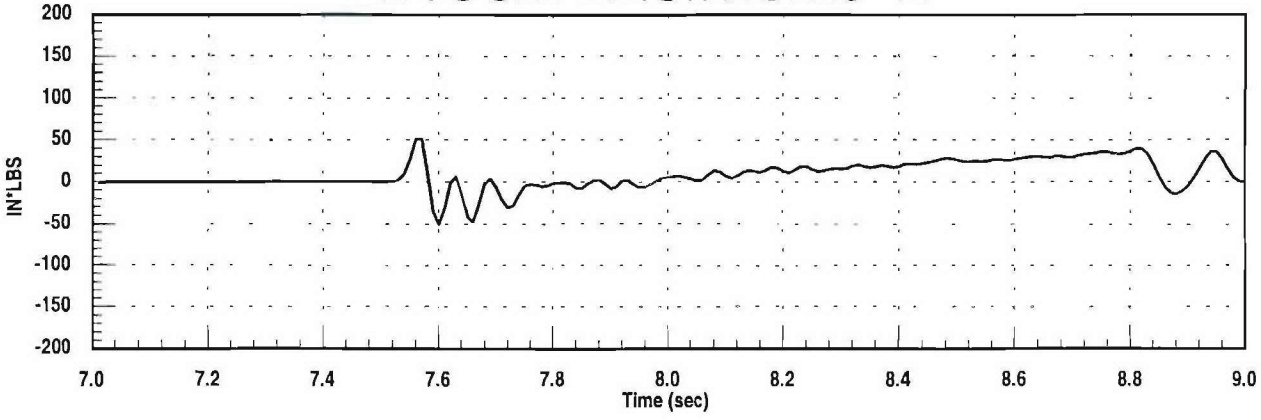
WD1A, 350 KEAS

T-38 Baseline / Hybrid III

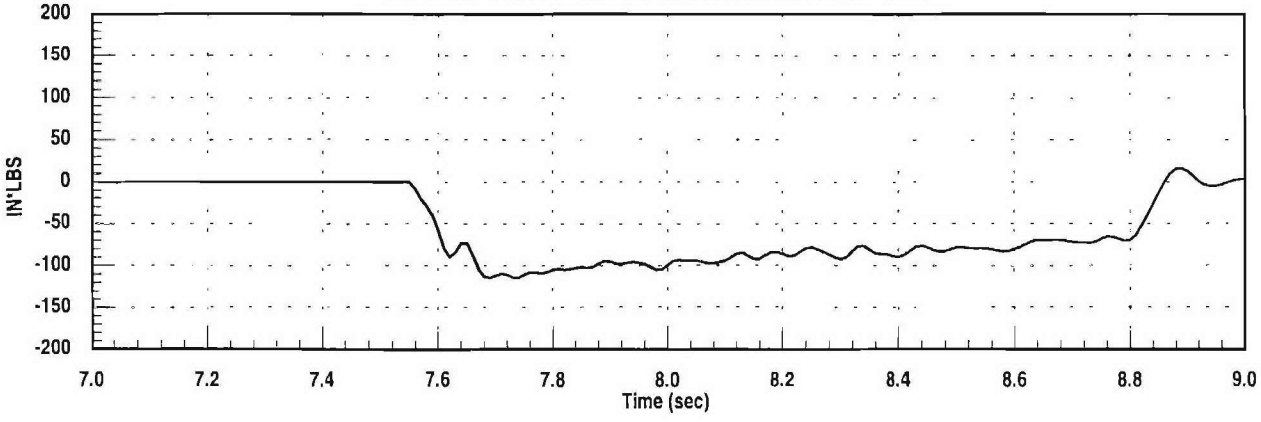
Neck Moment X



Neck Moment Y



Neck Moment Z



WD2, 375 KEAS

T-38 Baseline / Torso Rake

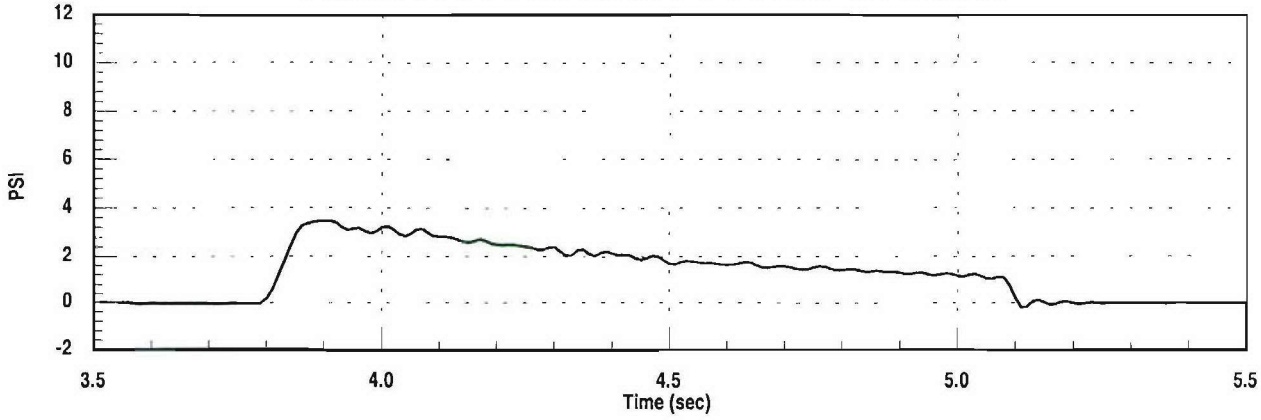
Processed Data

Main Rake Pressure	E-10
Row 1 Sensor 1 & 2 Pressures	E-11
Row 1 Sensor 3 & 4 Pressures	E-12
Row 2 Sensor 1 & 2 Pressures	E-13
Row 2 Sensor 3 & 4 Pressures	E-14
Row 3 Sensor 1 & 2 Pressures	E-15
Row 3 Sensor 3 & 4 Pressures	E-16
Row 4 Sensor 1 & 2 Pressures	E-17
Row 4 Sensor 3 & 4 Pressures	E-18
Row 5 Sensor 1 & 2 Pressures	E-19
Row 5 Sensor 3 & 4 Pressures	E-20

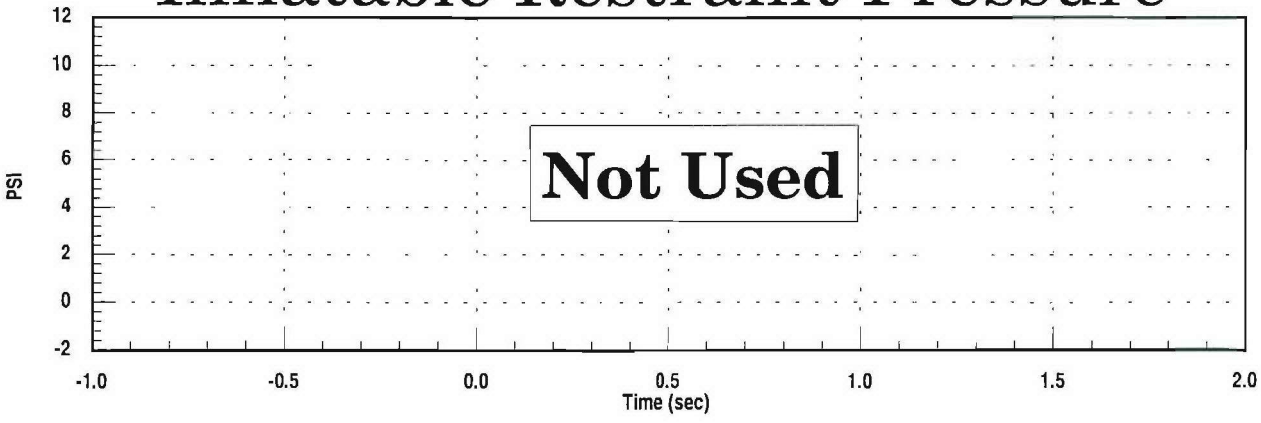
WD2, 375 KEAS

T-38 Baseline / Torso Rake

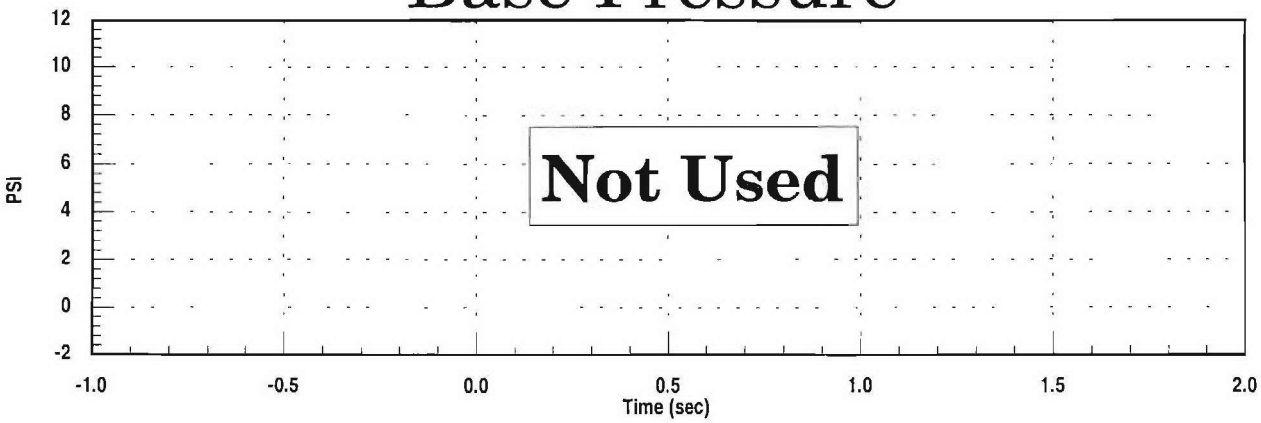
Main Rake Pressure



Inflatable Restraint Pressure



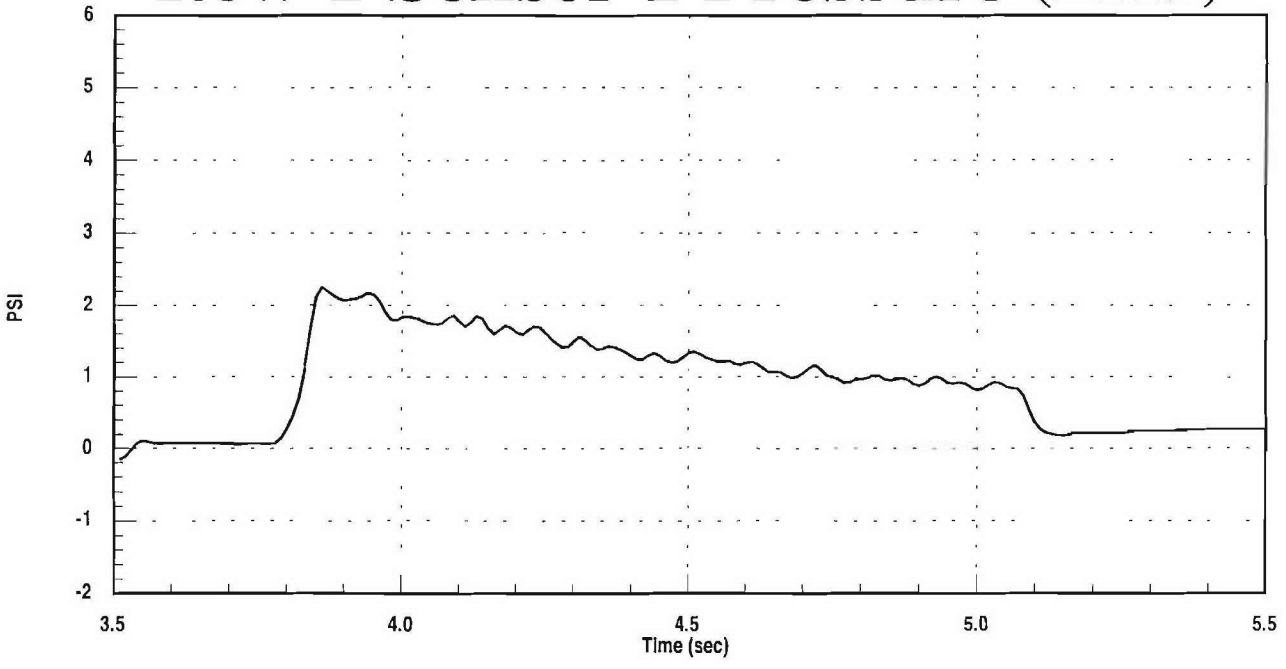
Base Pressure



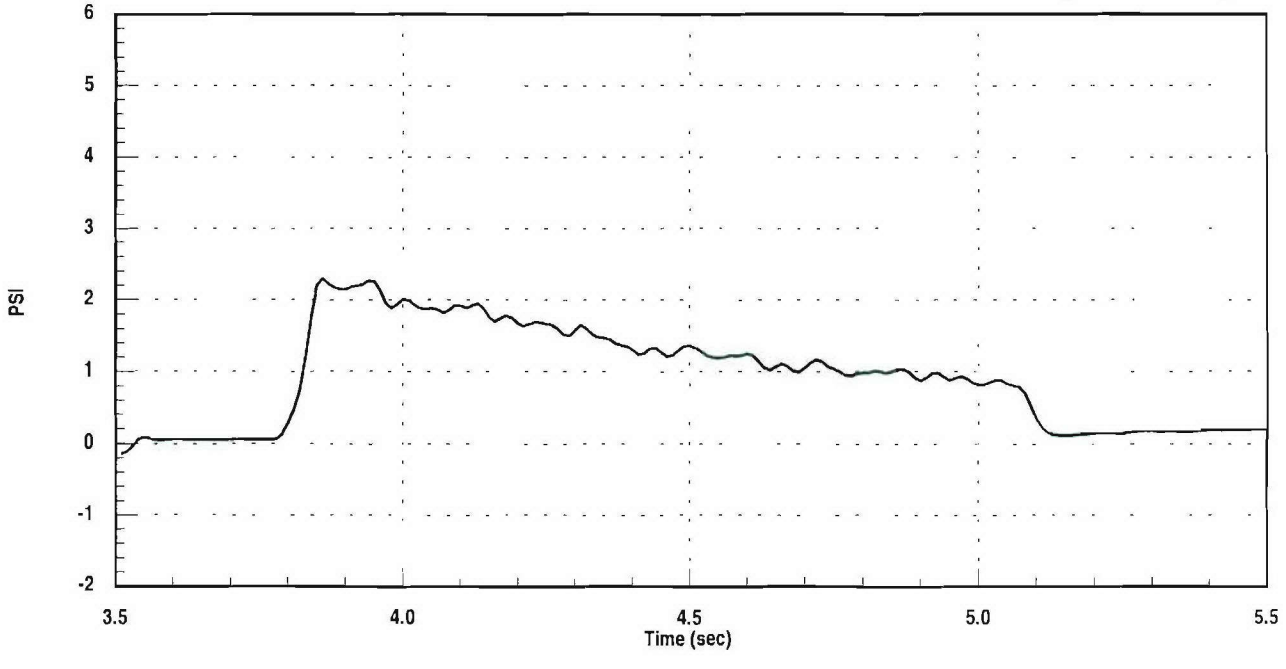
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



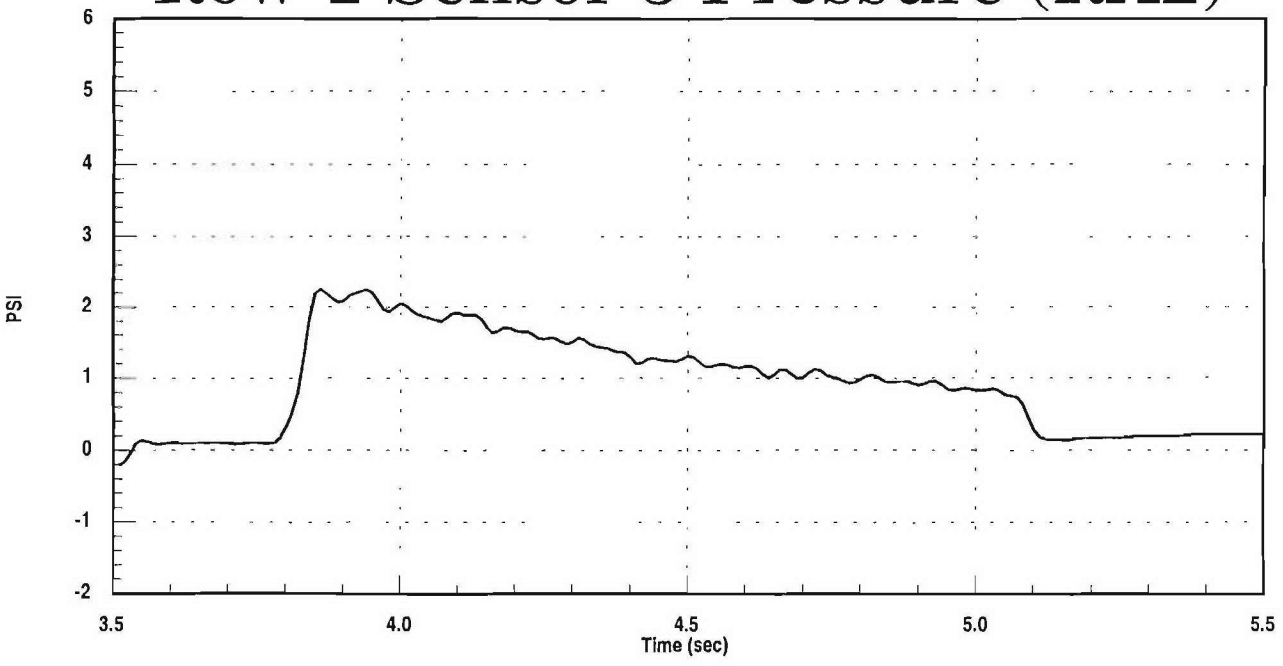
Row 1 Sensor 2 Pressure (LA2)



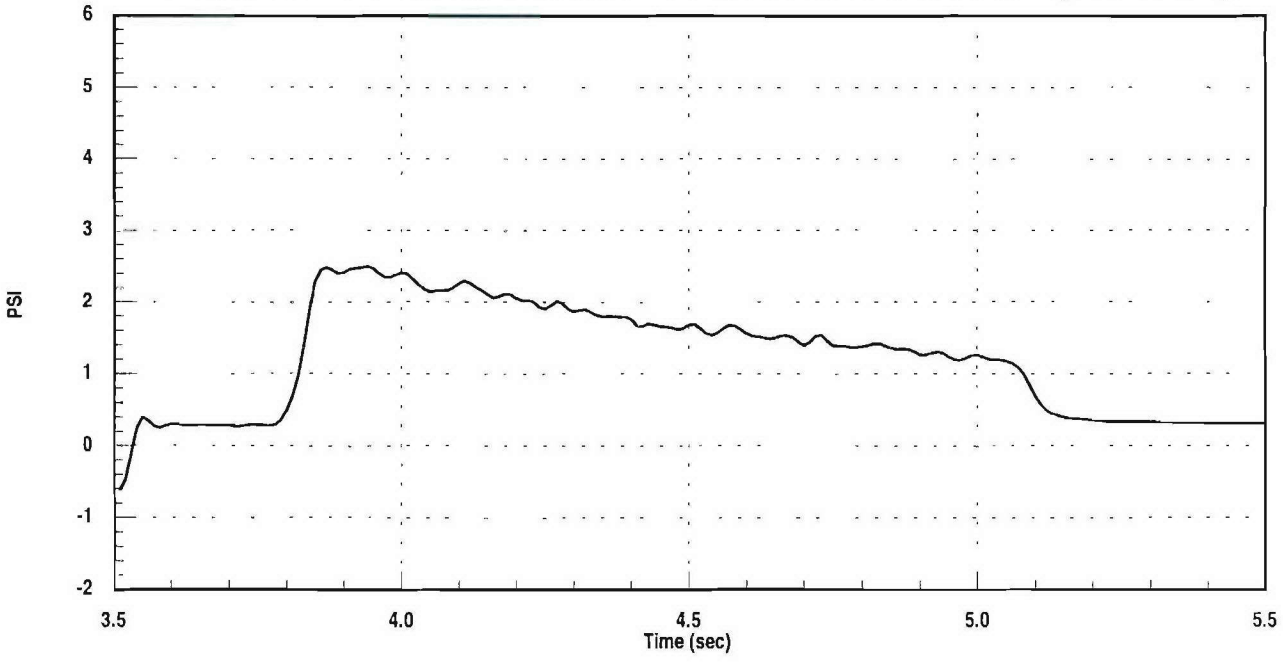
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



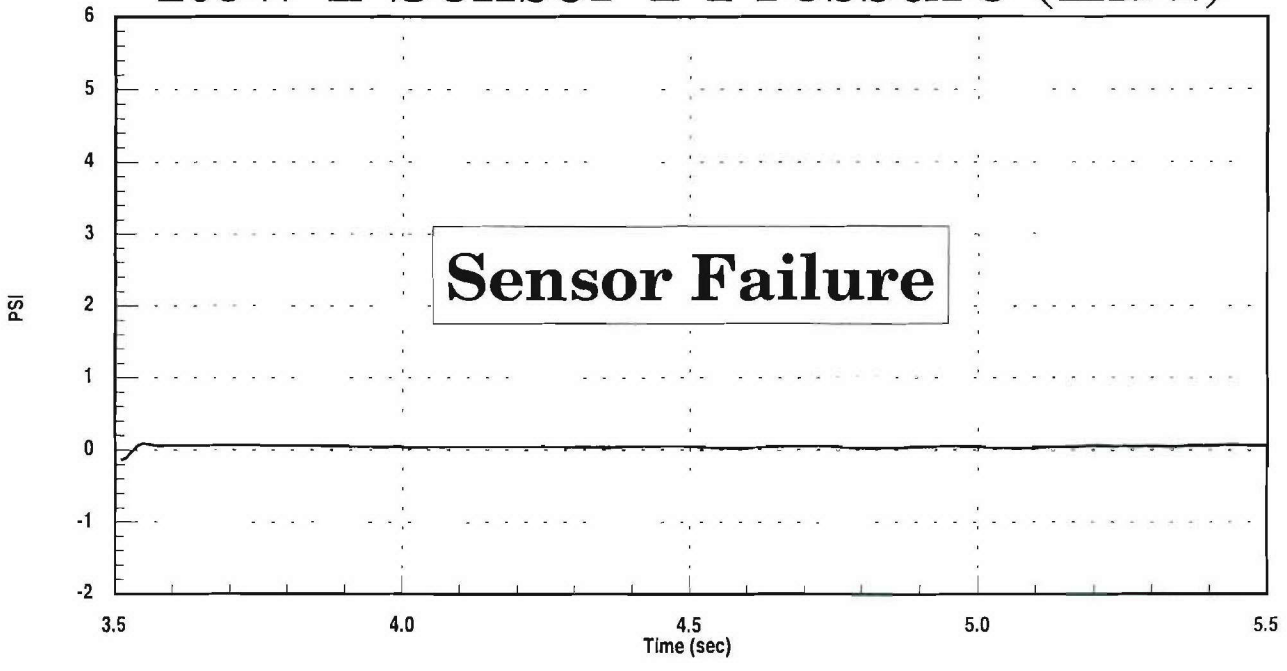
Row 1 Sensor 4 Pressure (RA1)



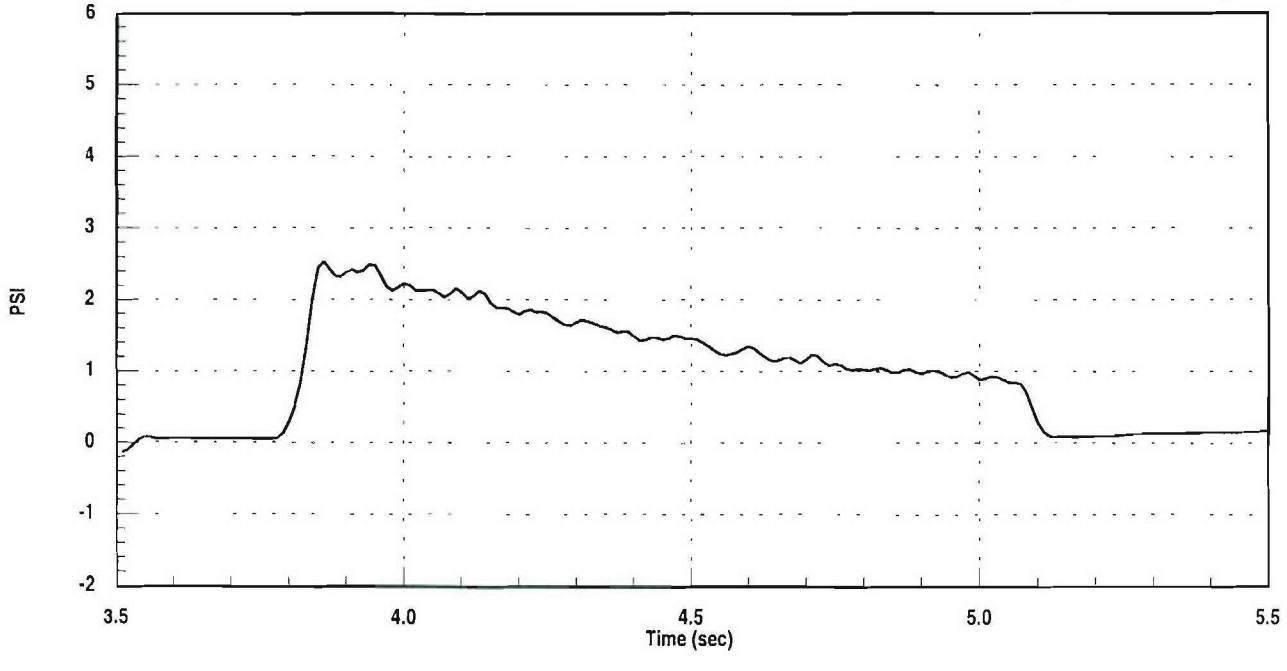
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



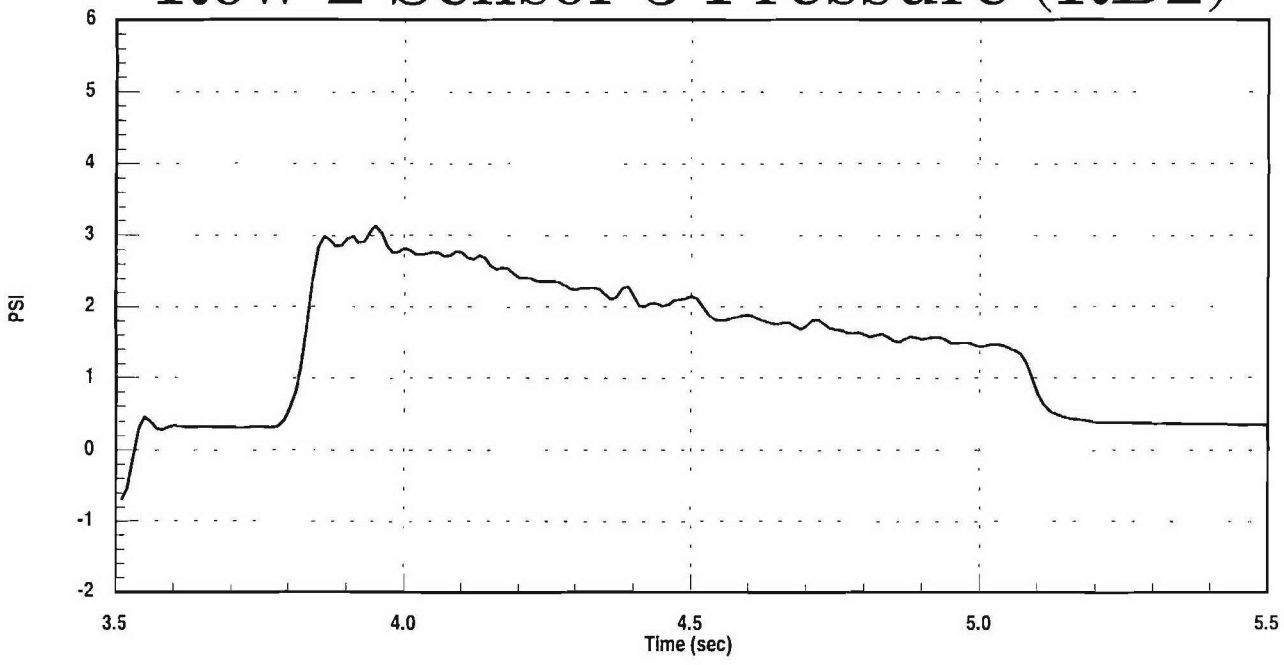
Row 2 Sensor 2 Pressure (LB2)



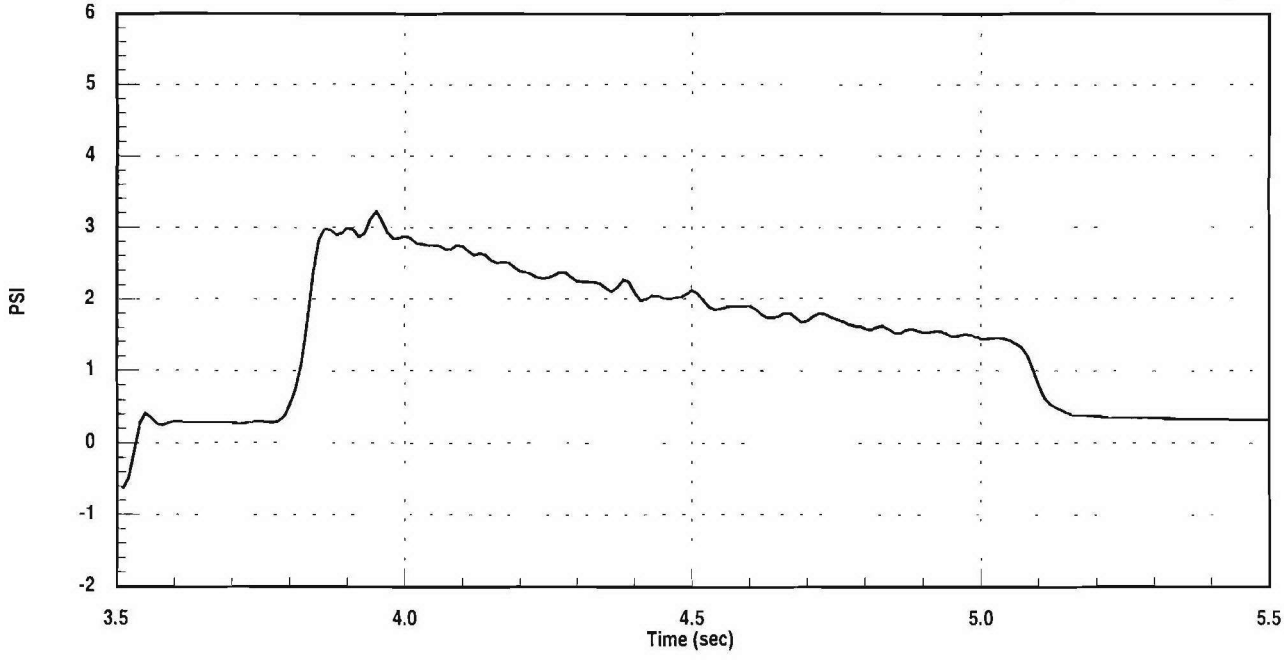
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



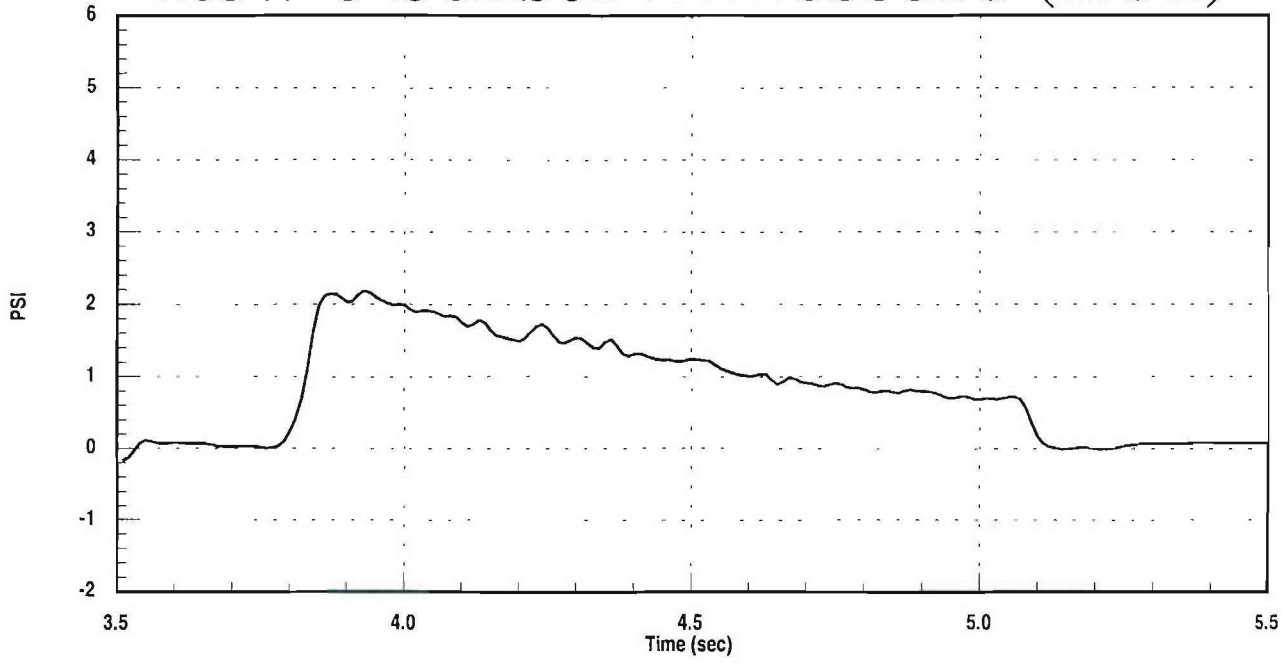
Row 2 Sensor 4 Pressure (RB1)



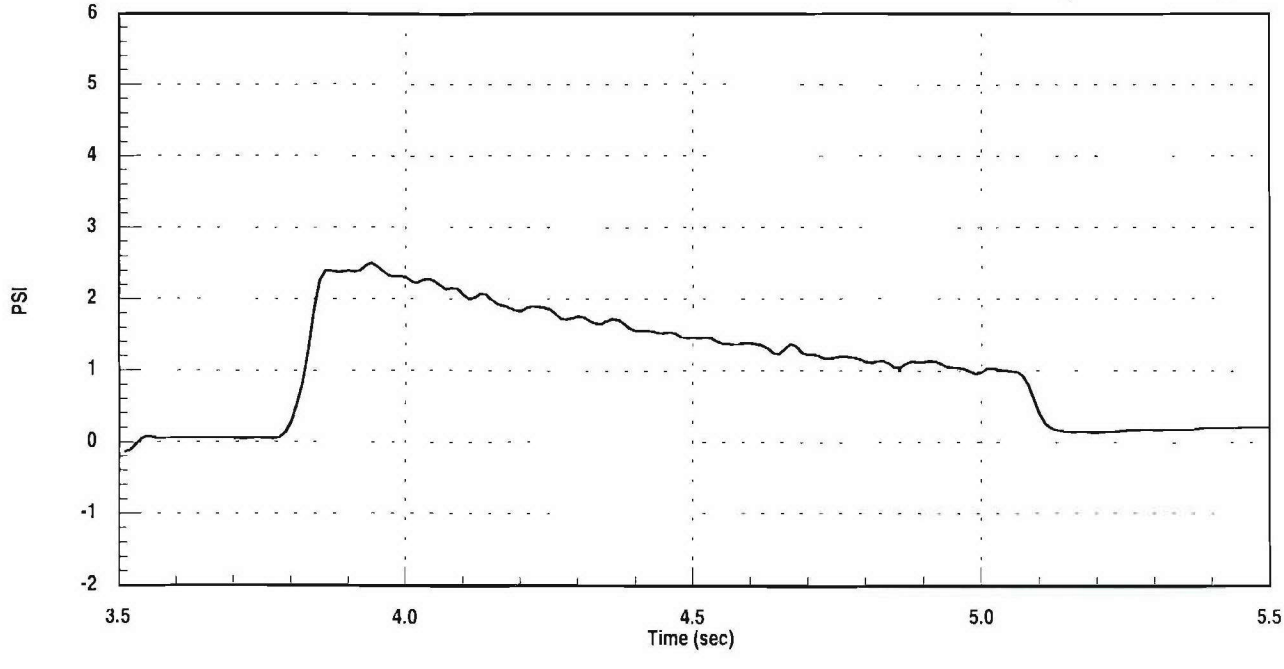
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



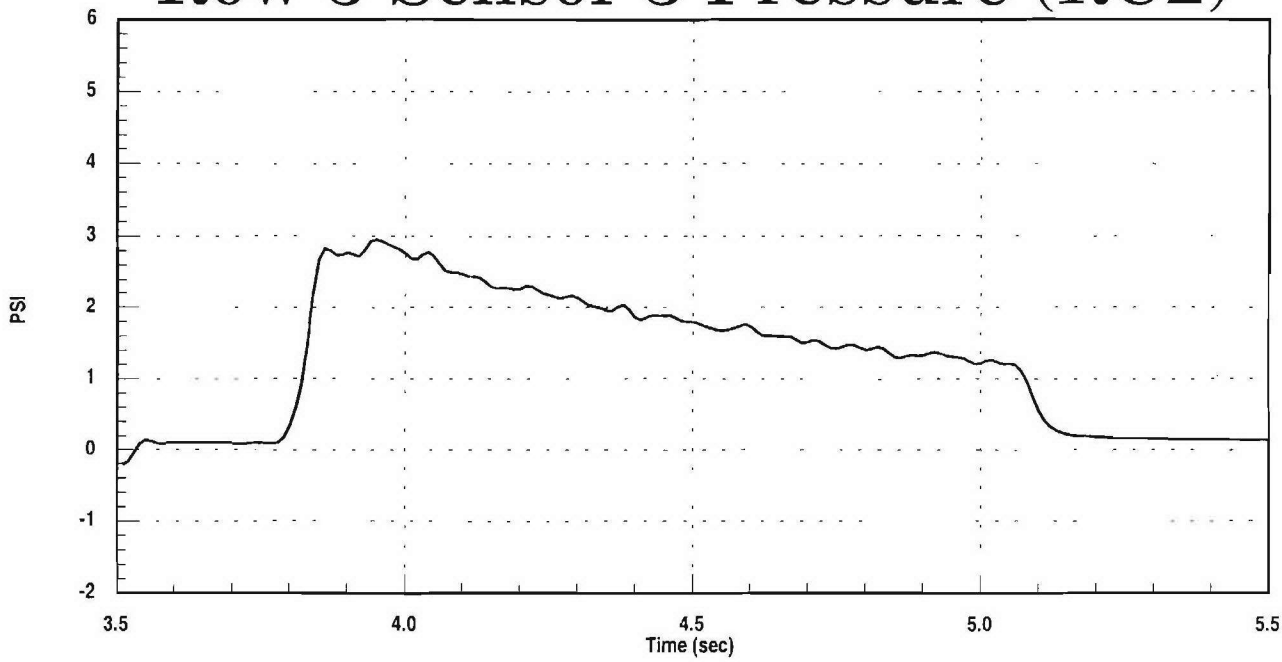
Row 3 Sensor 2 Pressure (LC2)



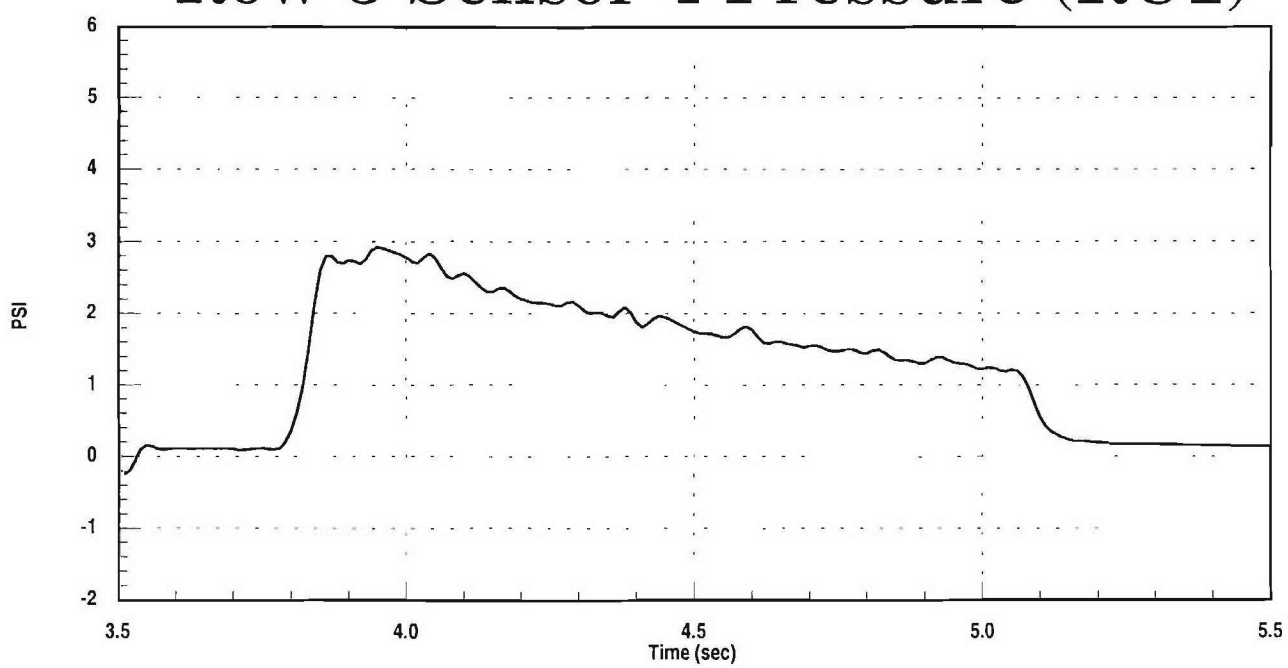
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



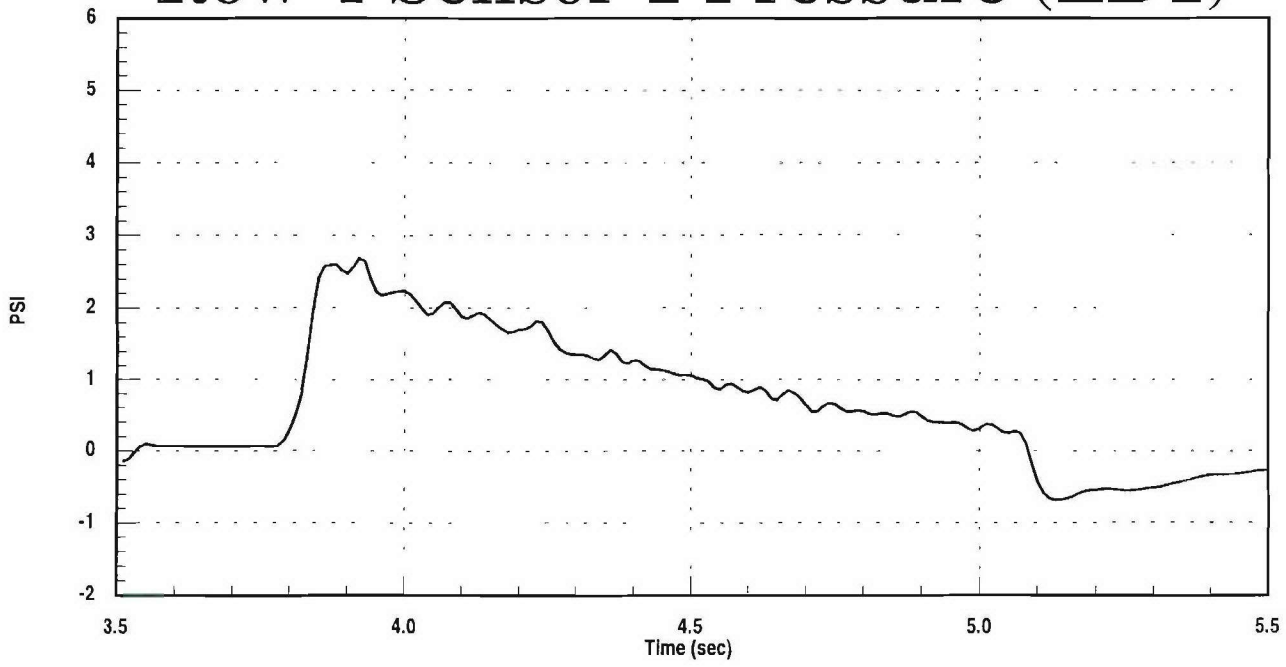
Row 3 Sensor 4 Pressure (RC1)



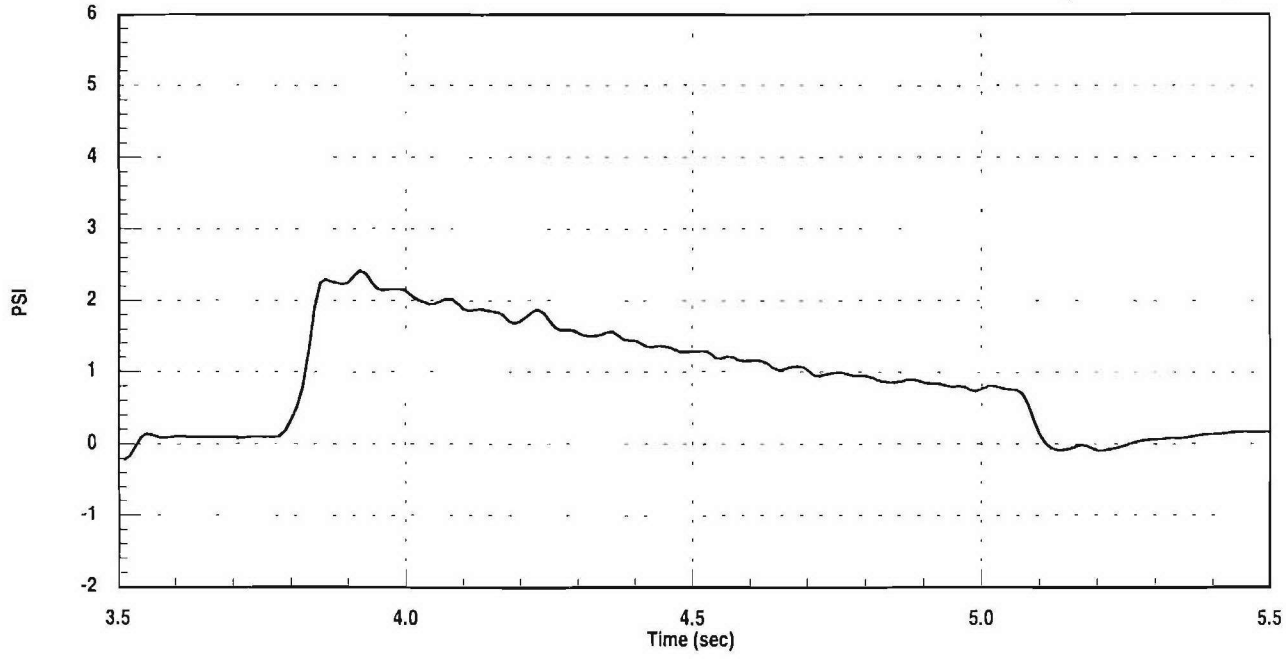
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



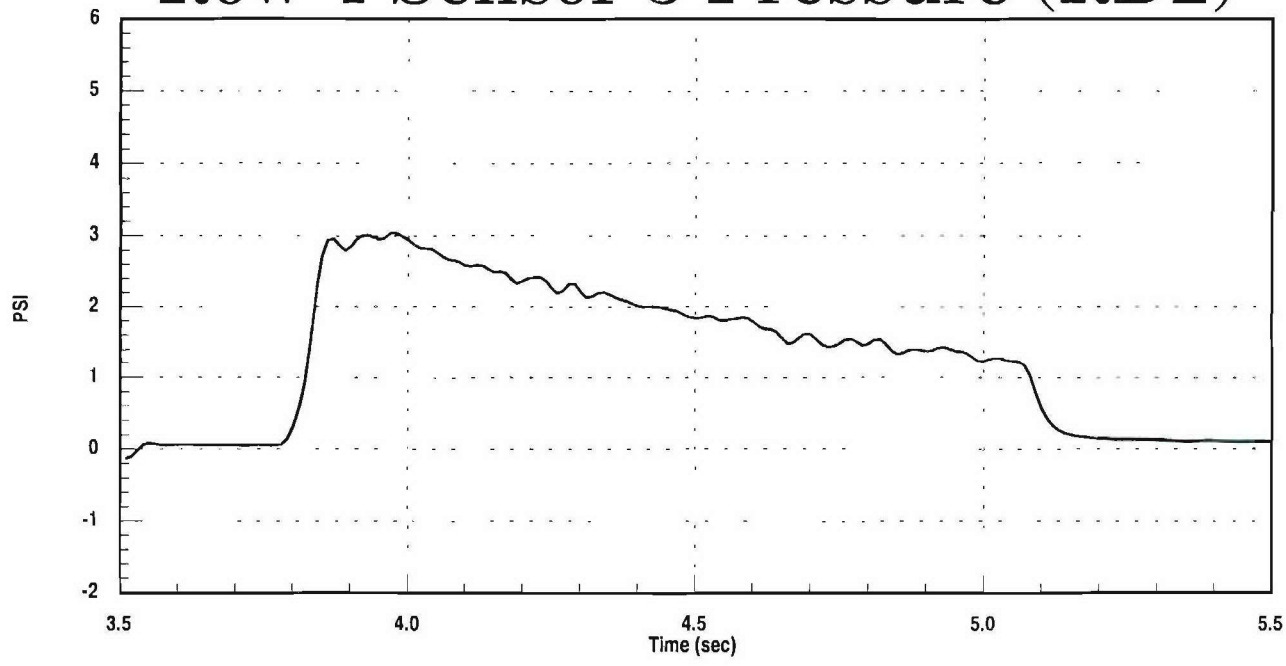
Row 4 Sensor 2 Pressure (LD2)



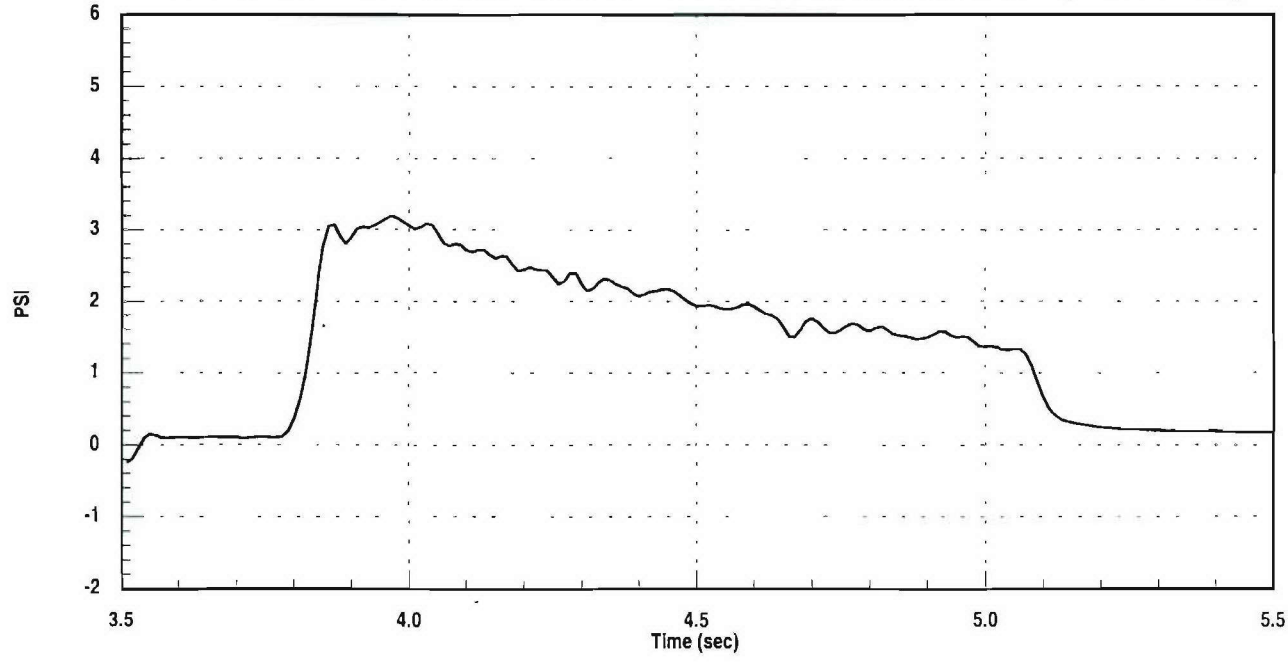
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



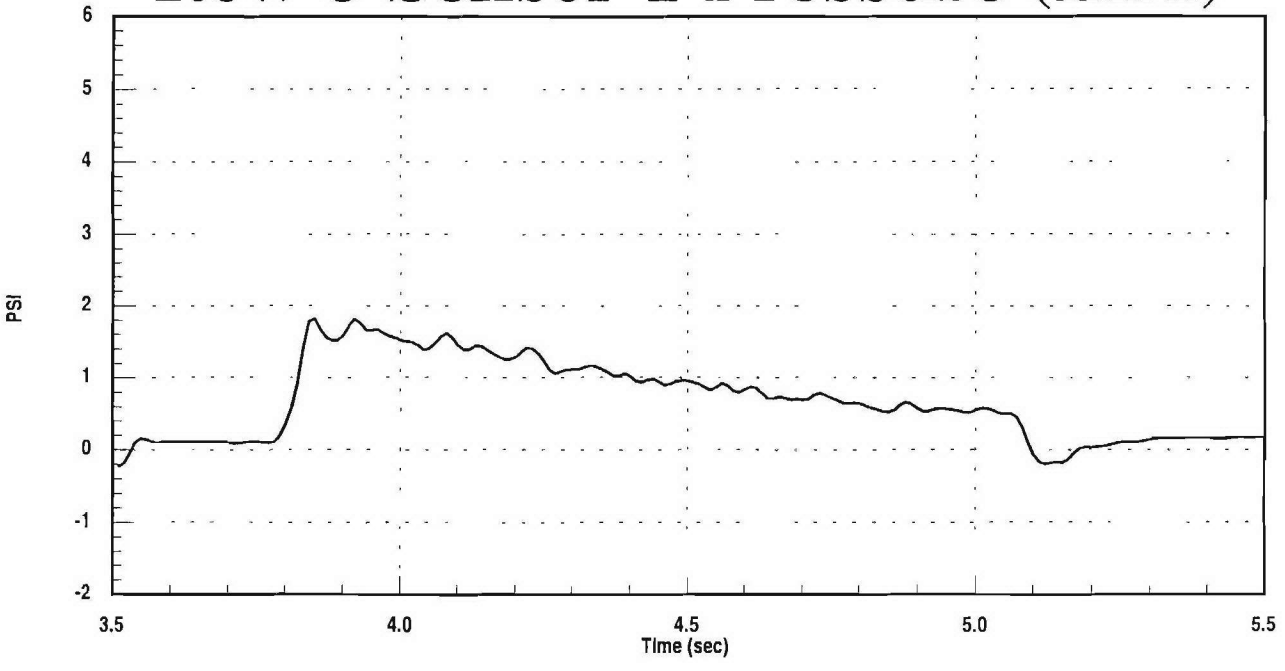
Row 4 Sensor 4 Pressure (RD1)



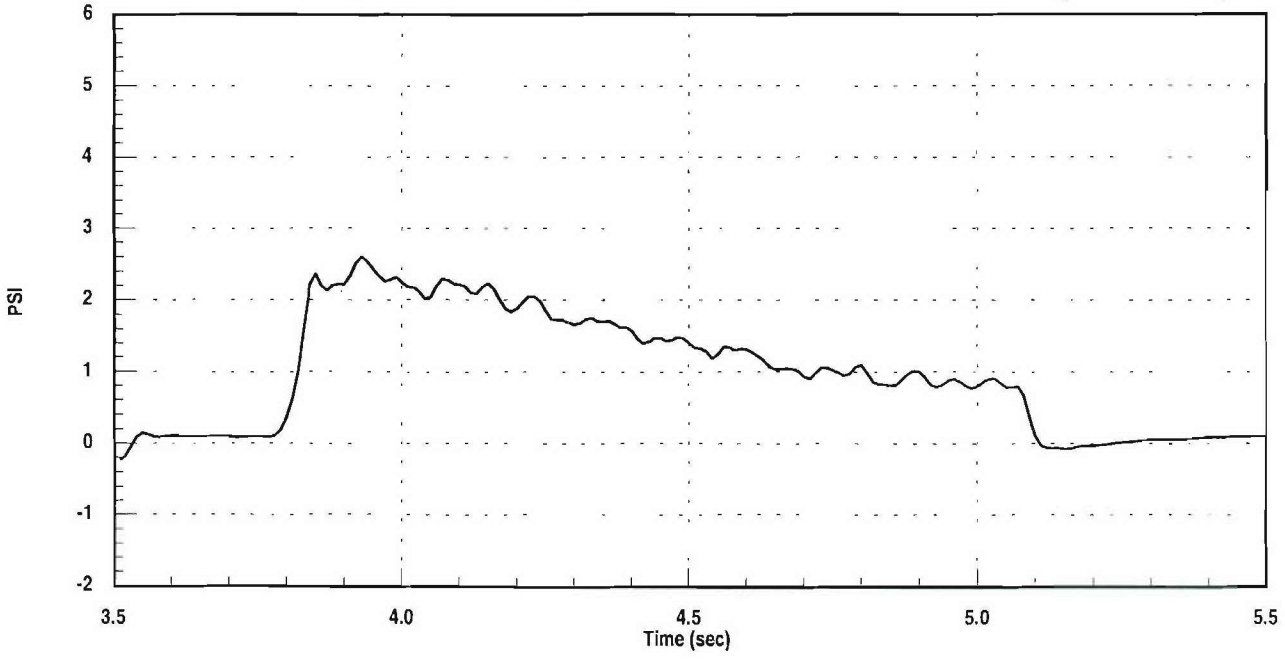
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



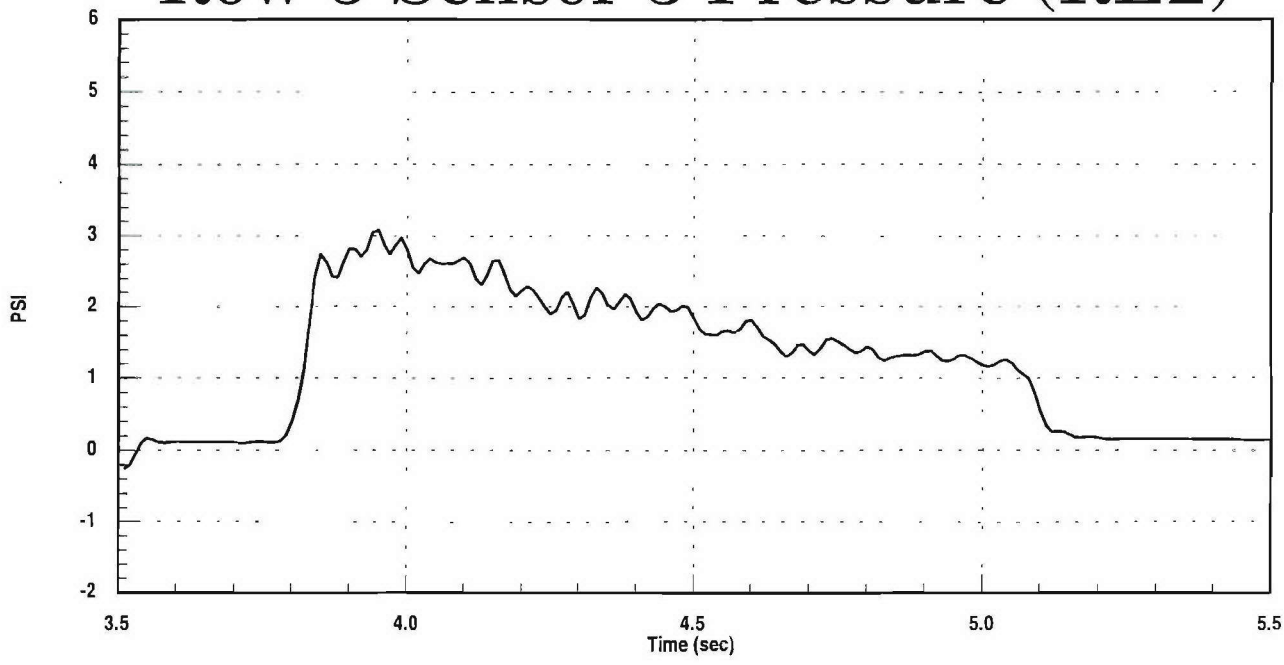
Row 5 Sensor 2 Pressure (LE2)



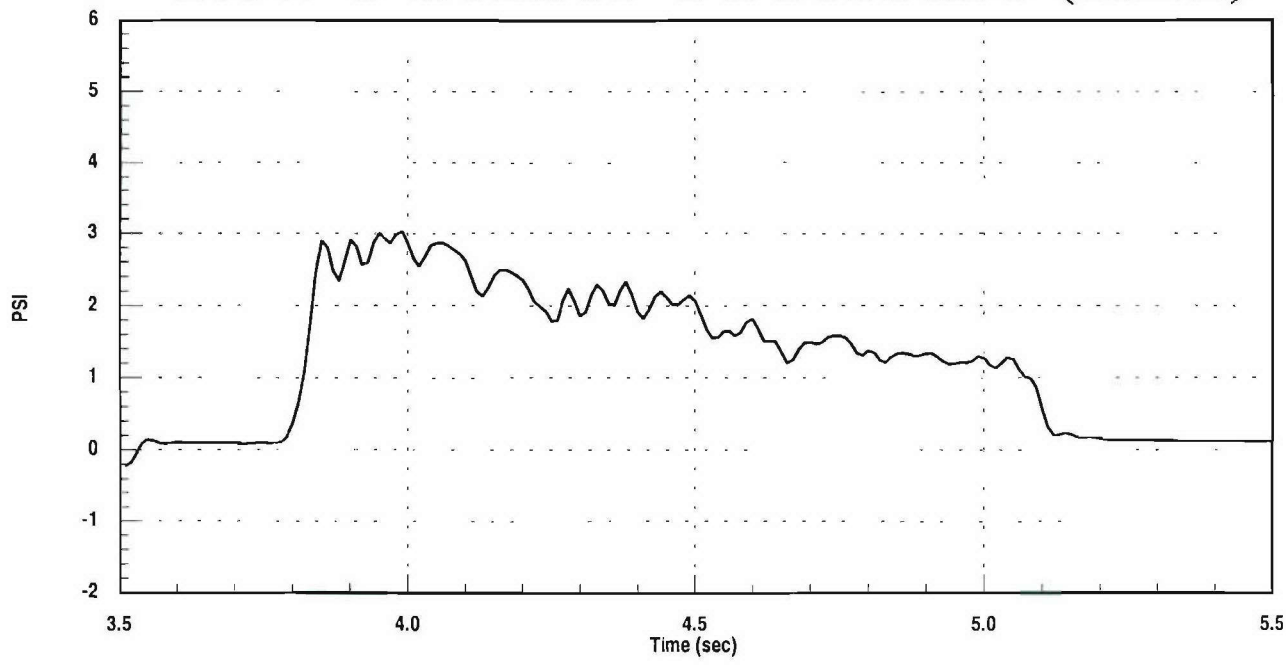
WD2, 375 KEAS

T-38 Baseline / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

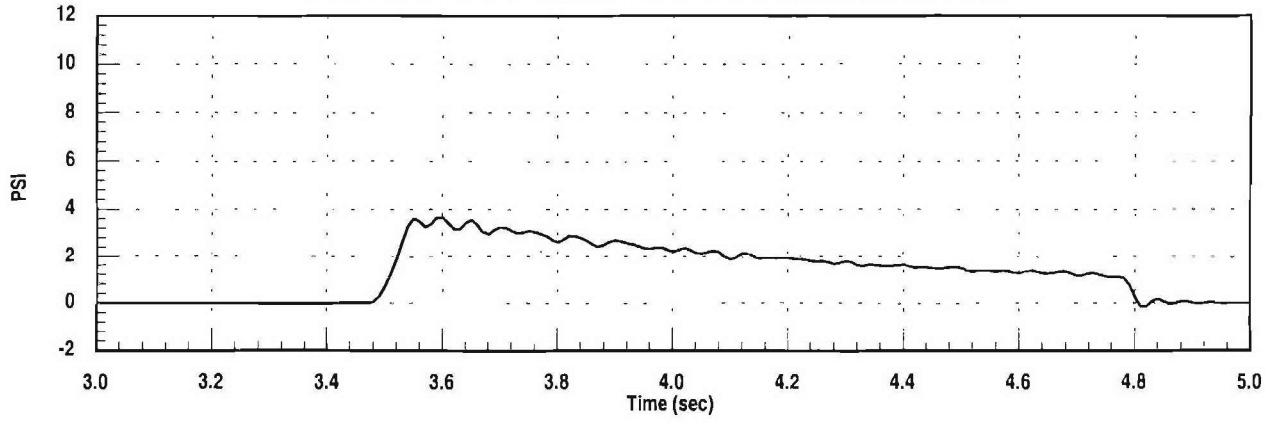
Processed Data

Main Rake and Inflatable Restraint Inner Pressure	E-22
Row 1 Sensor 1 & 2 Pressures	E-23
Row 1 Sensor 3 & 4 Pressures	E-24
Row 2 Sensor 1 & 2 Pressures	E-25
Row 2 Sensor 3 & 4 Pressures	E-26
Row 3 Sensor 1 & 2 Pressures	E-27
Row 3 Sensor 3 & 4 Pressures	E-28
Row 4 Sensor 1 & 2 Pressures	E-29
Row 4 Sensor 3 & 4 Pressures	E-30
Row 5 Sensor 1 & 2 Pressures	E-31
Row 5 Sensor 3 & 4 Pressures	E-32

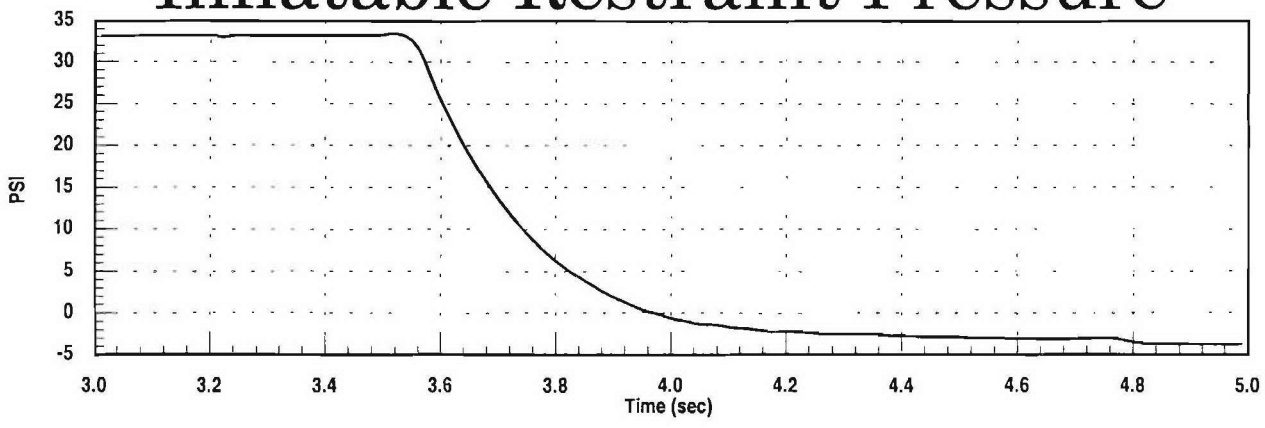
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

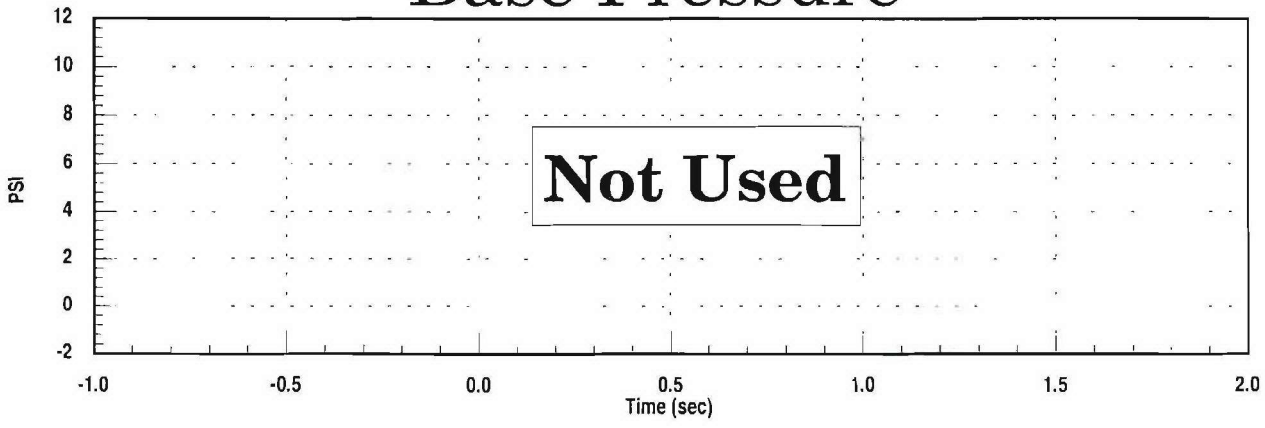
Main Rake Pressure



Inflatable Restraint Pressure



Base Pressure

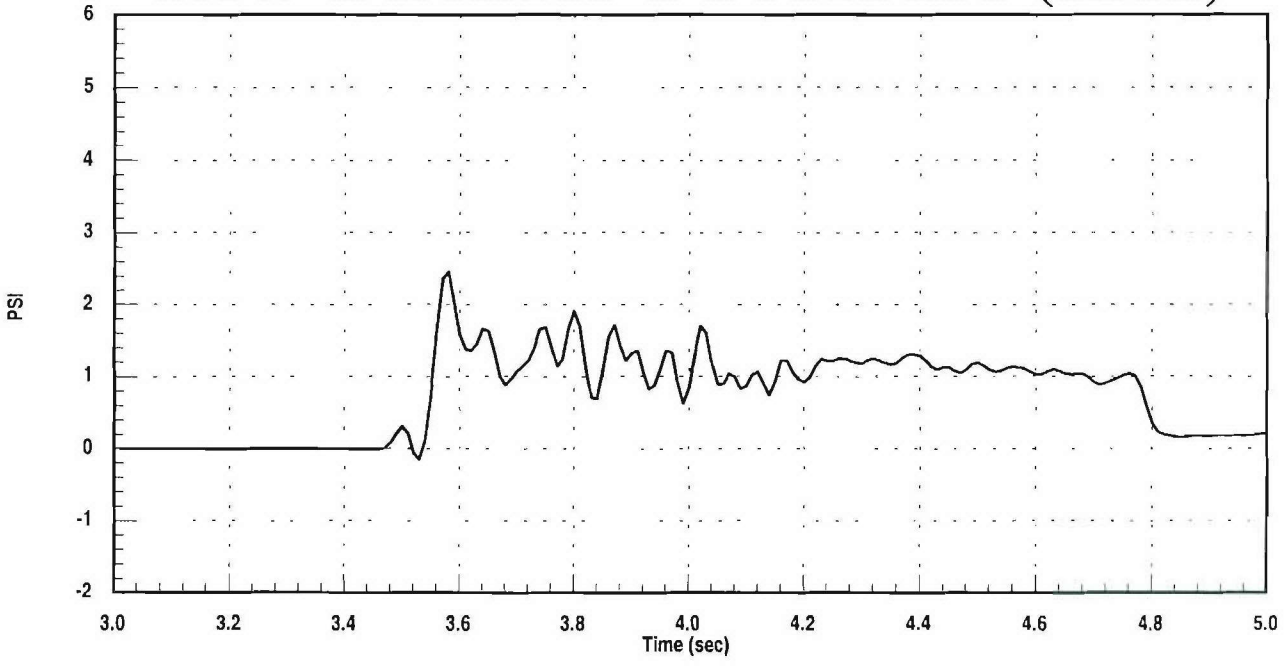


E-22

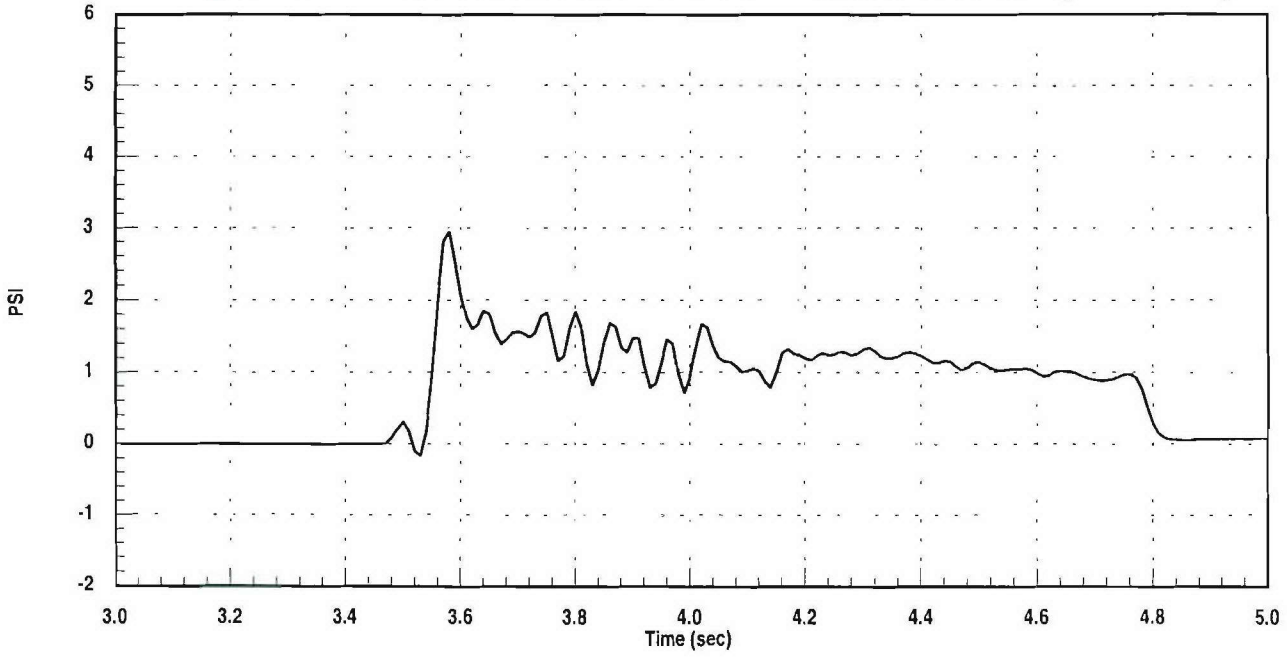
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



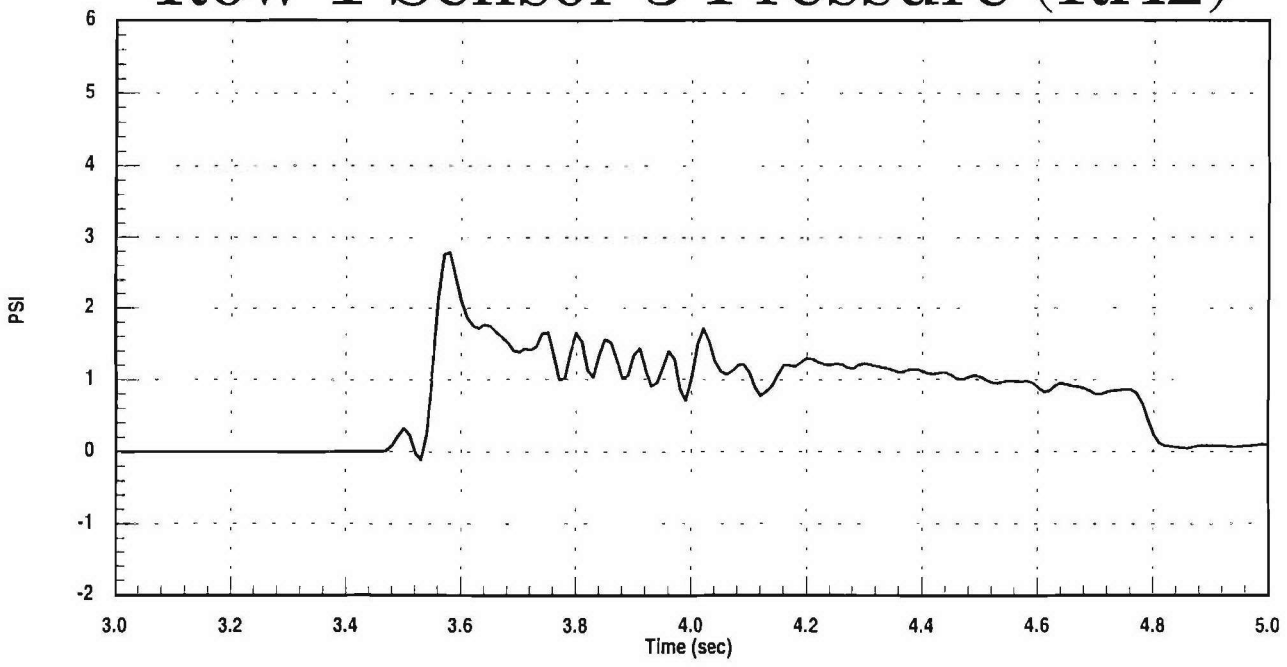
Row 1 Sensor 2 Pressure (LA2)



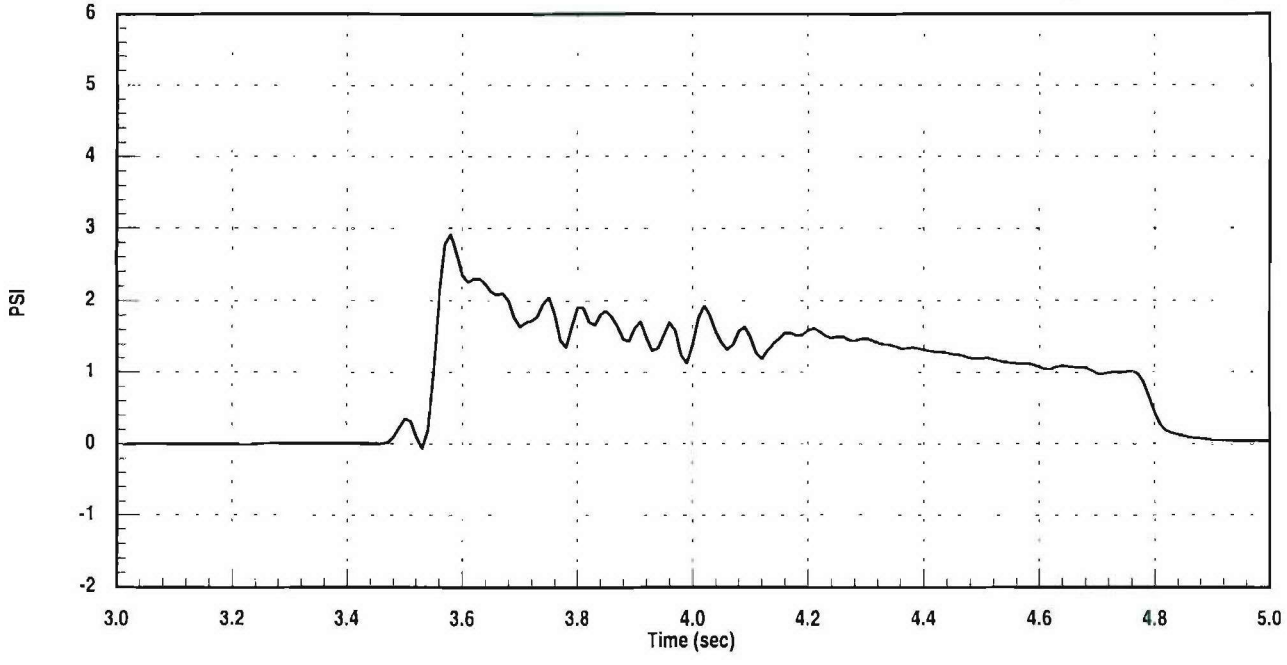
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



Row 1 Sensor 4 Pressure (RA1)

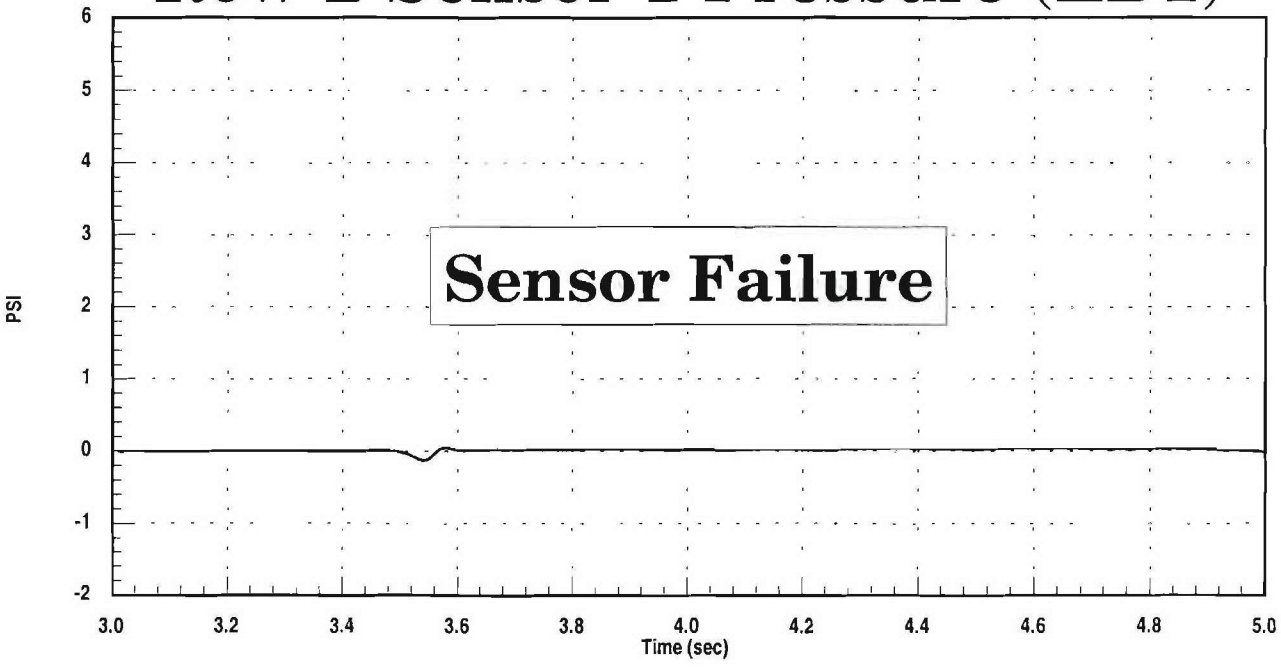


E-24

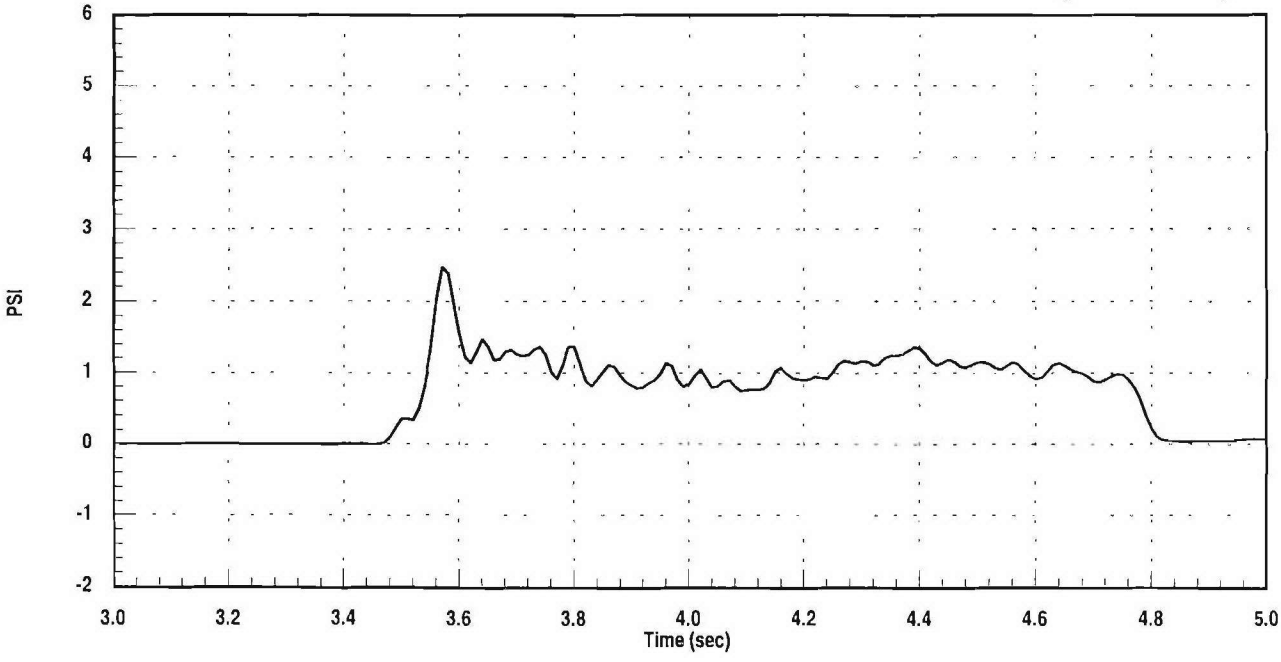
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



Row 2 Sensor 2 Pressure (LB2)

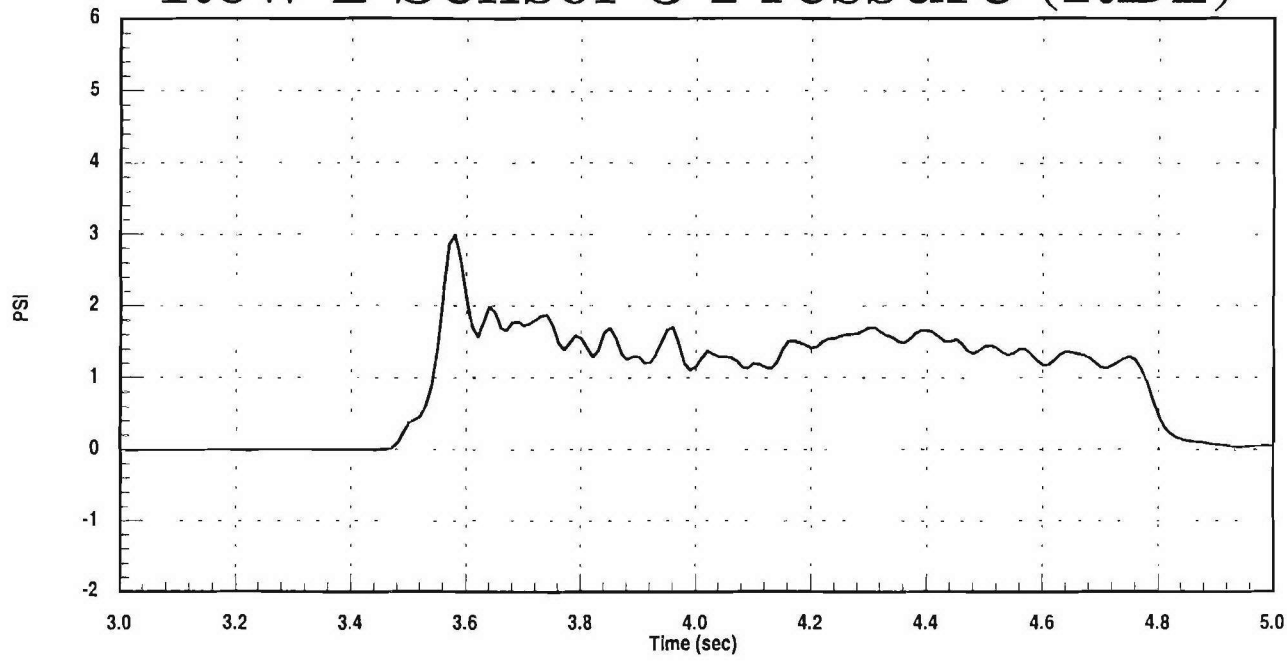


E-25

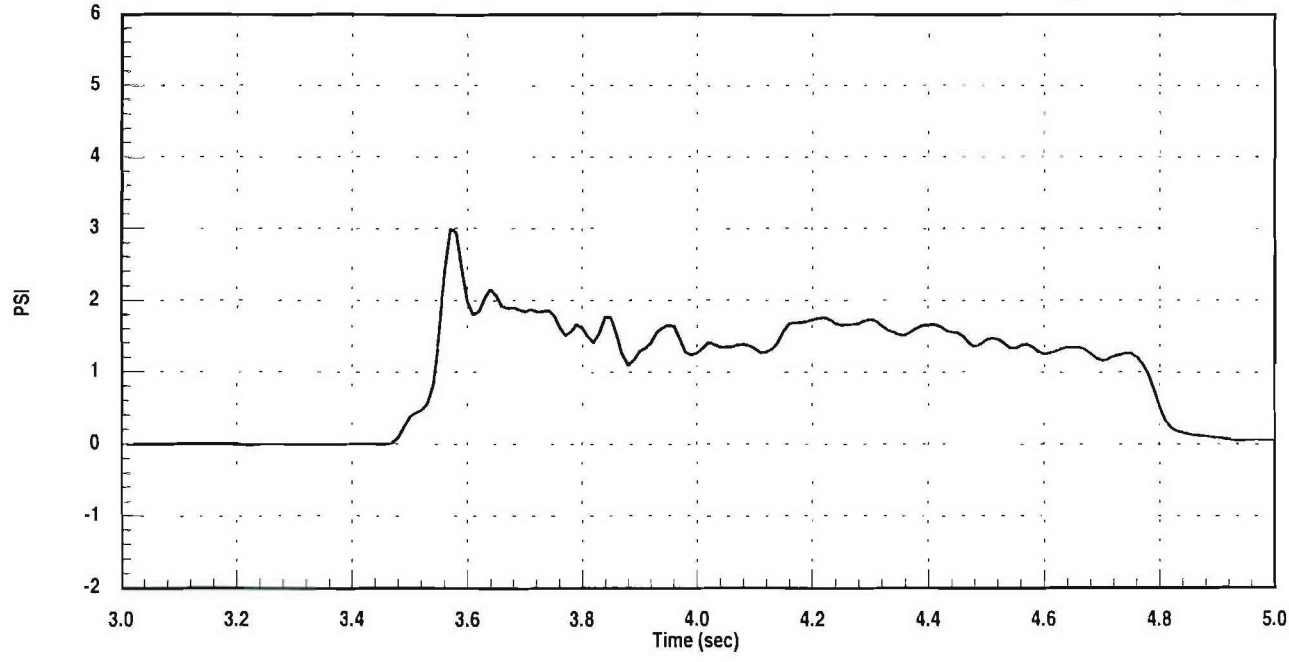
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



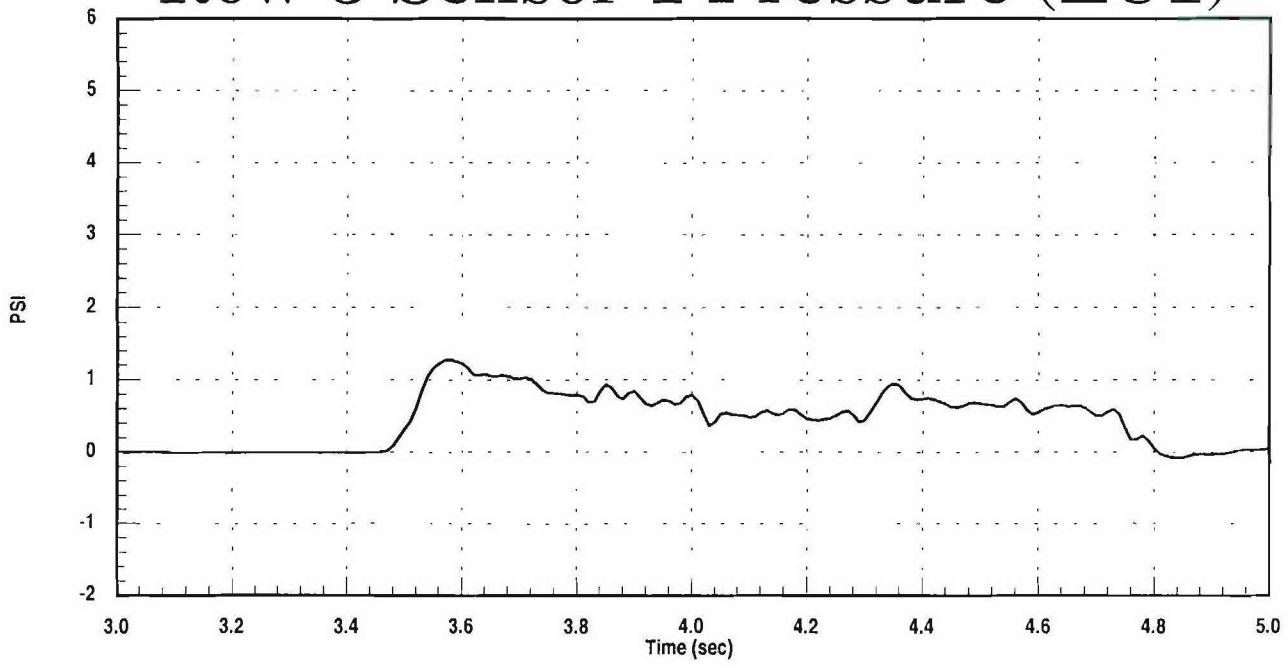
Row 2 Sensor 4 Pressure (RB1)



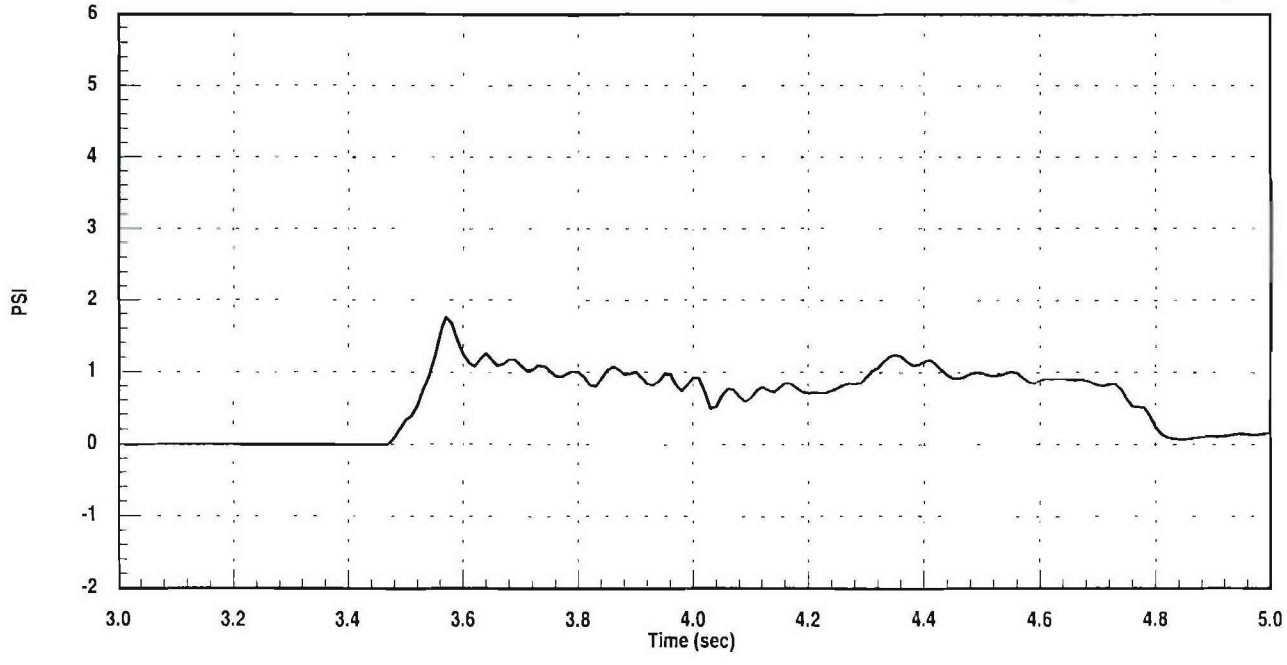
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



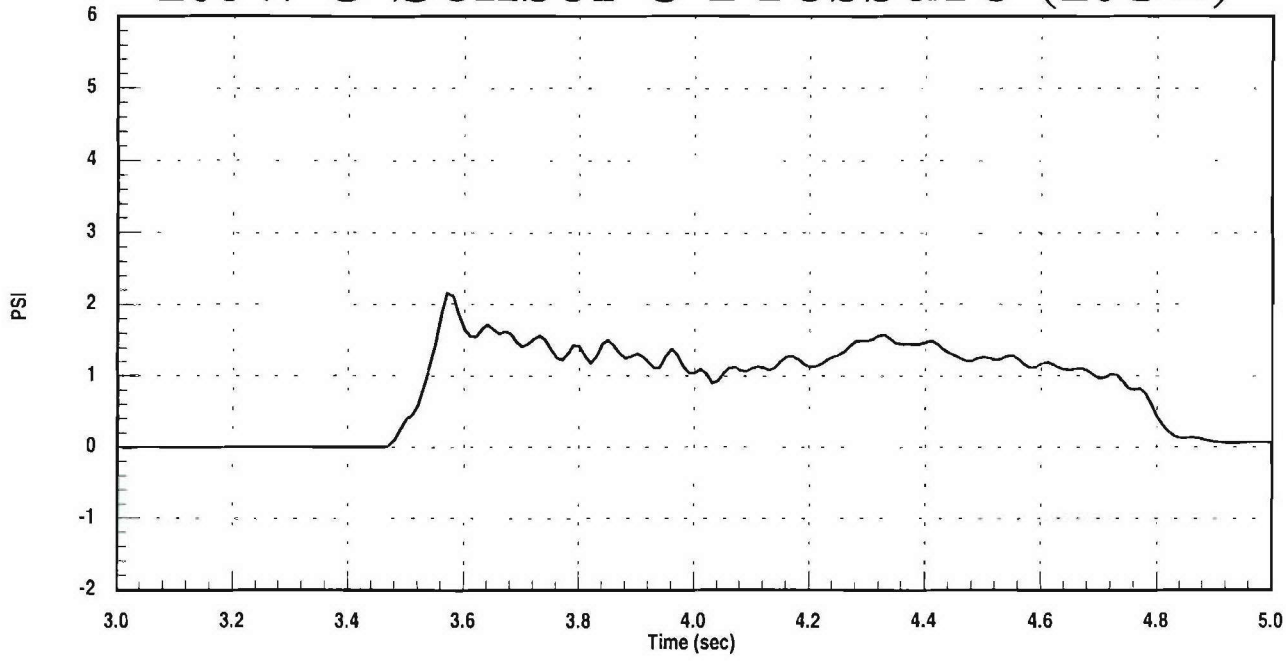
Row 3 Sensor 2 Pressure (LC2)



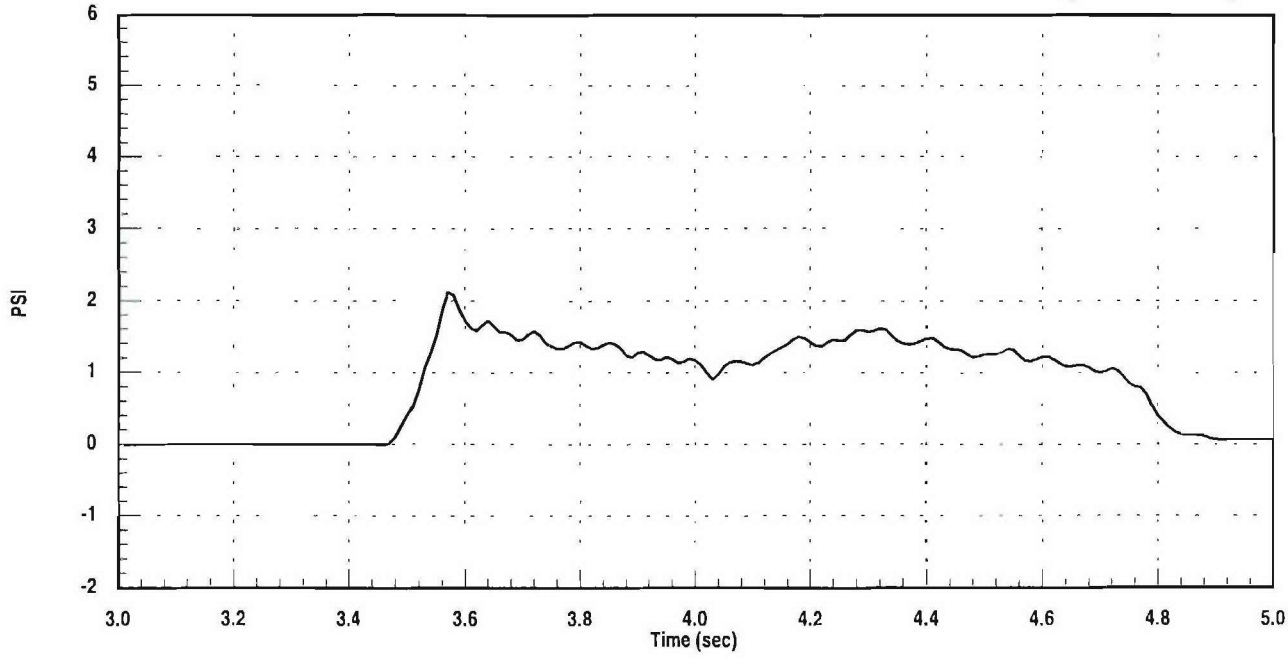
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



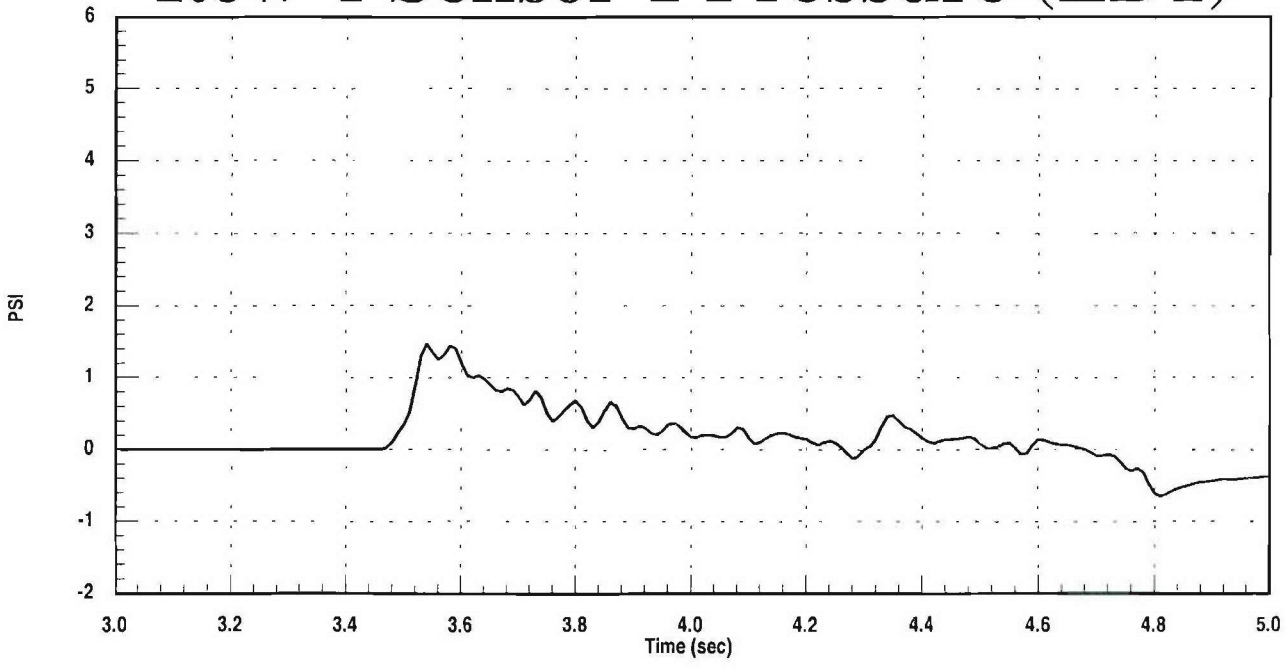
Row 3 Sensor 4 Pressure (RC1)



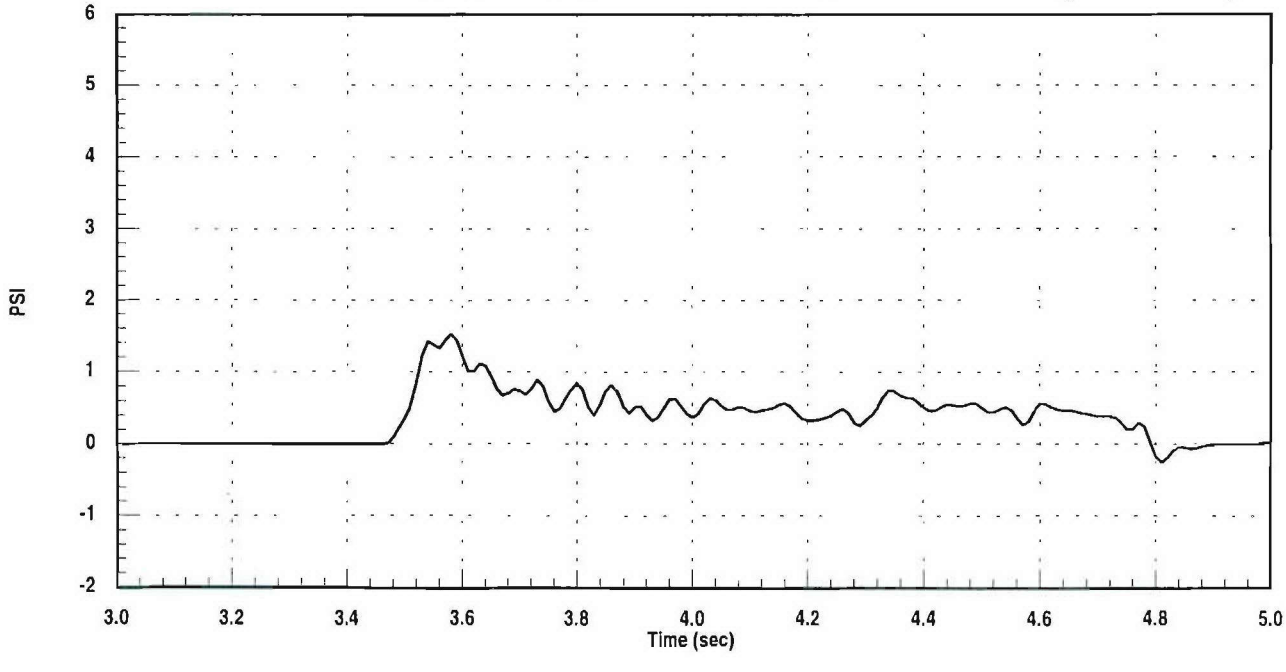
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



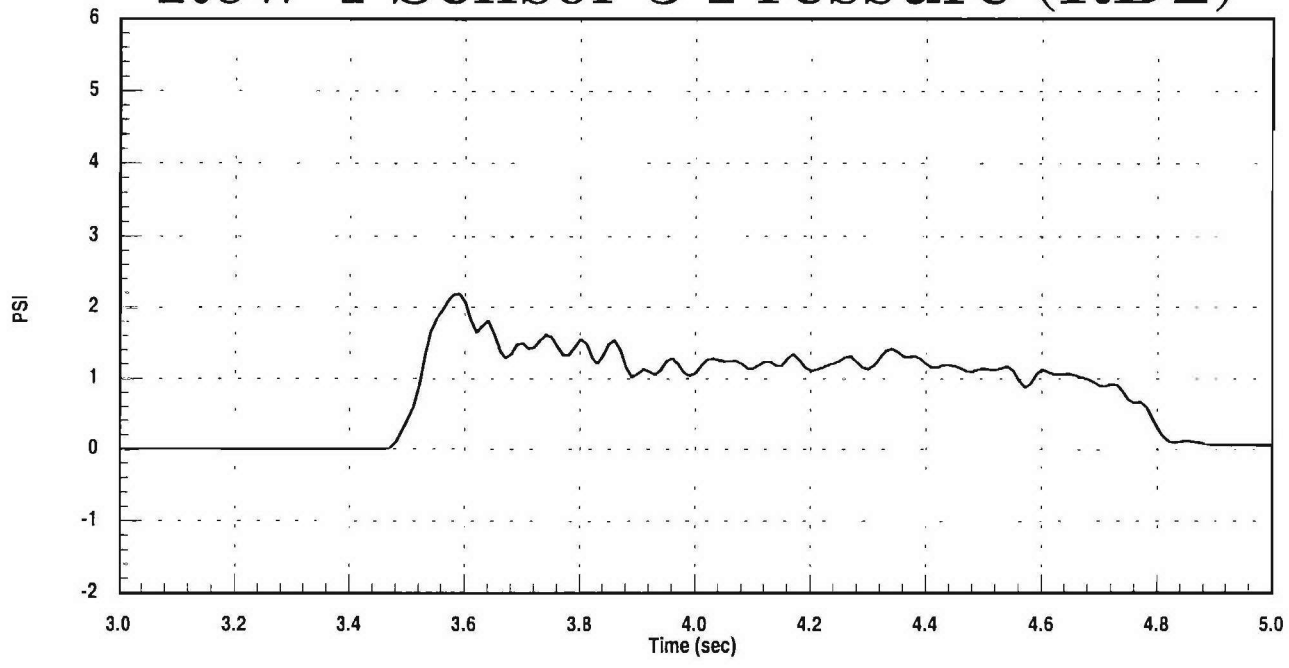
Row 4 Sensor 2 Pressure (LD2)



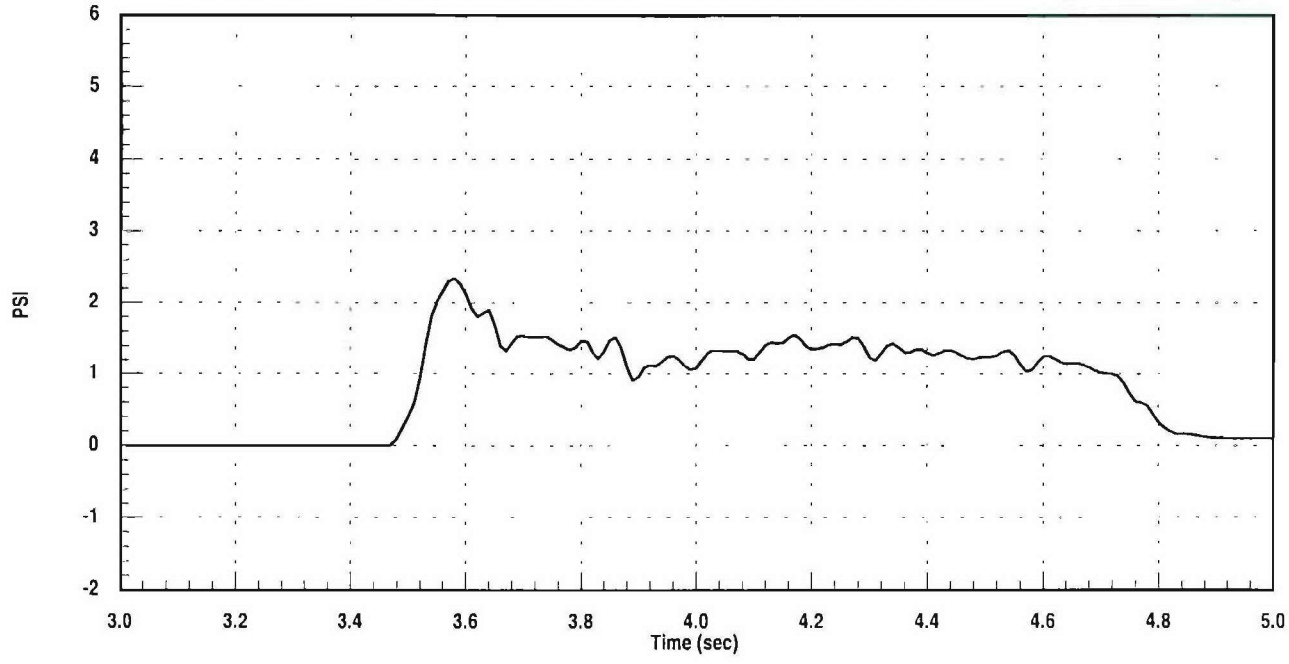
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



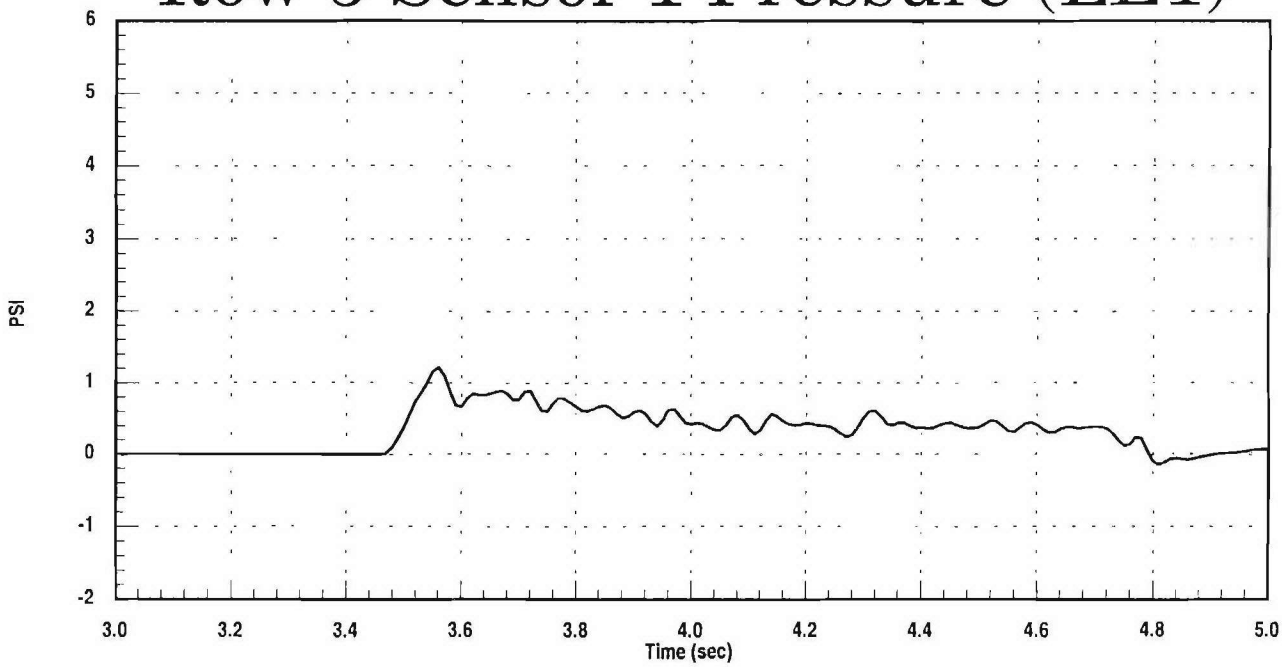
Row 4 Sensor 4 Pressure (RD1)



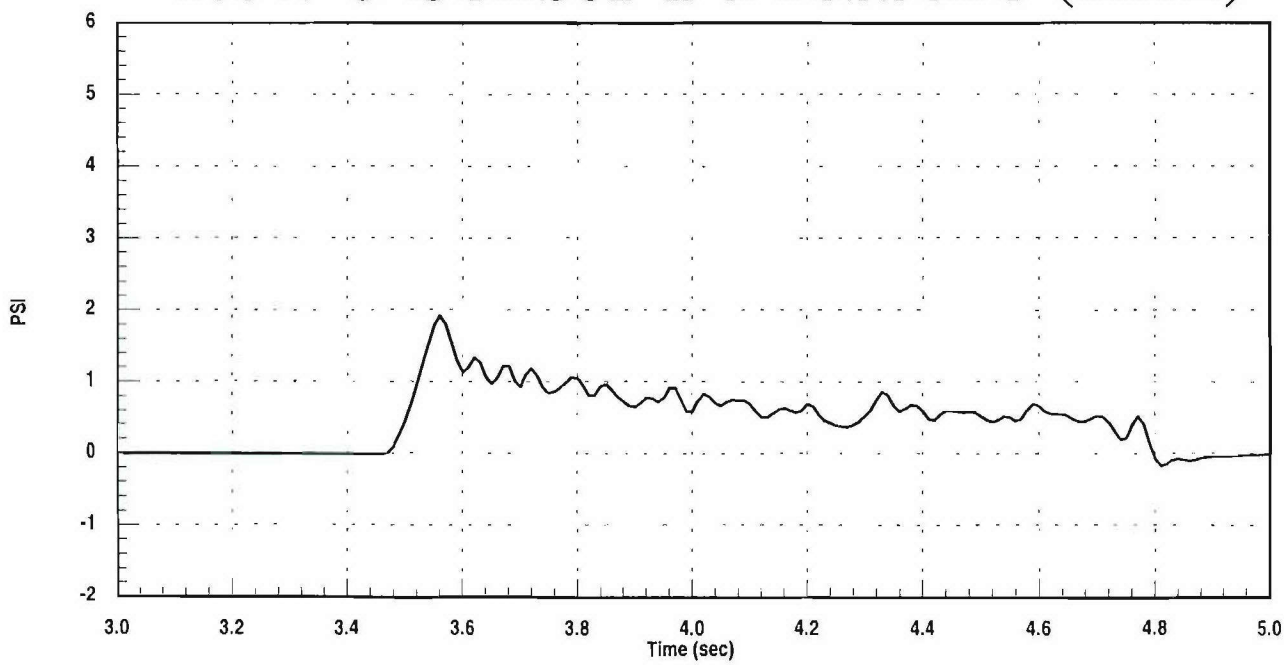
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



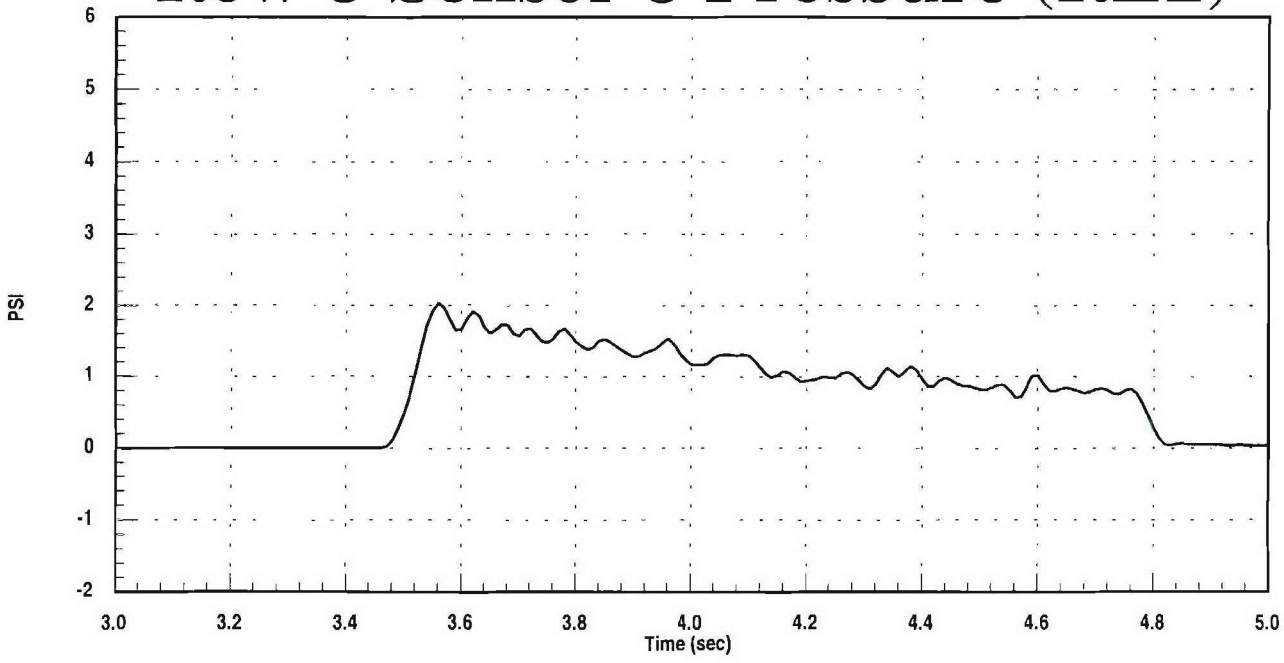
Row 5 Sensor 2 Pressure (LE2)



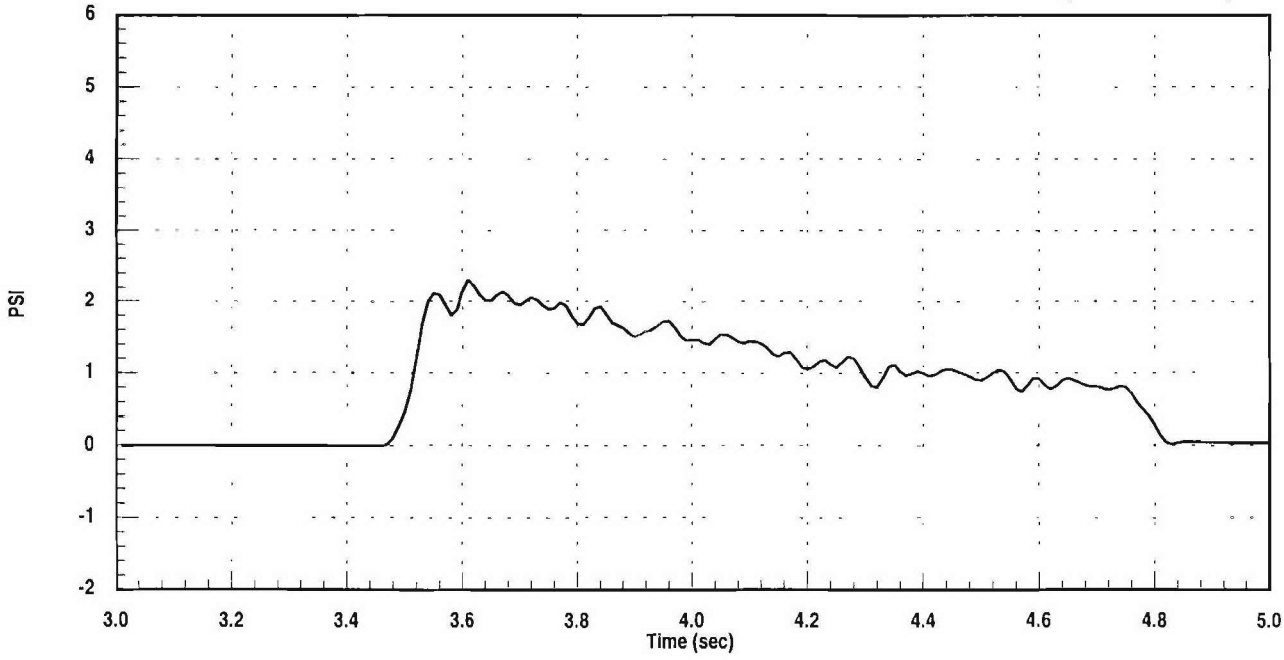
WD3, 375 KEAS

T-38 Truncated Cone / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



E-32

WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

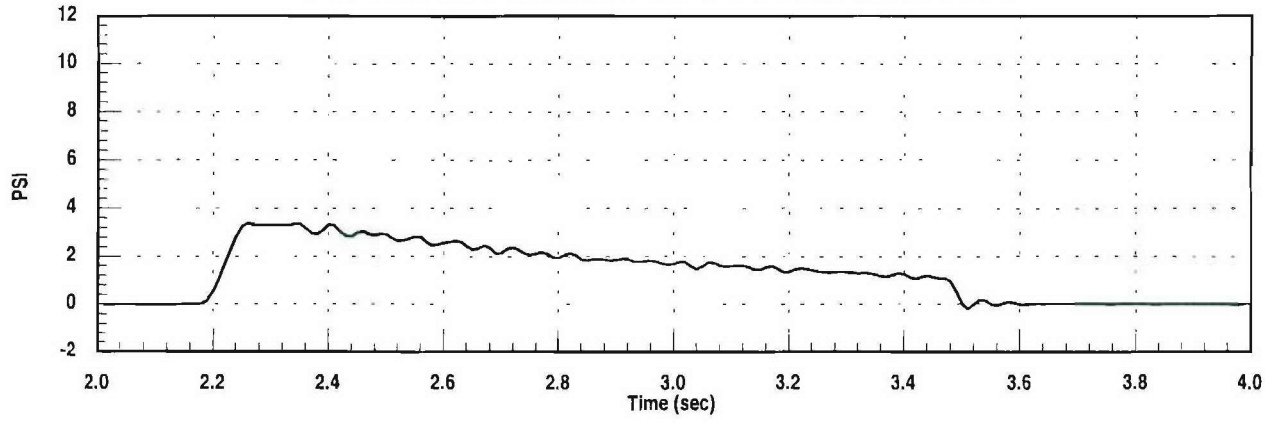
Processed Data

Main Rake Pressure	E-34
Row 1 Sensor 1 & 2 Pressures	E-35
Row 1 Sensor 3 & 4 Pressures	E-36
Row 2 Sensor 1 & 2 Pressures	E-37
Row 2 Sensor 3 & 4 Pressures	E-38
Row 3 Sensor 1 & 2 Pressures	E-39
Row 3 Sensor 3 & 4 Pressures	E-40
Row 4 Sensor 1 & 2 Pressures	E-41
Row 4 Sensor 3 & 4 Pressures	E-42
Row 5 Sensor 1 & 2 Pressures	E-43
Row 5 Sensor 3 & 4 Pressures	E-44

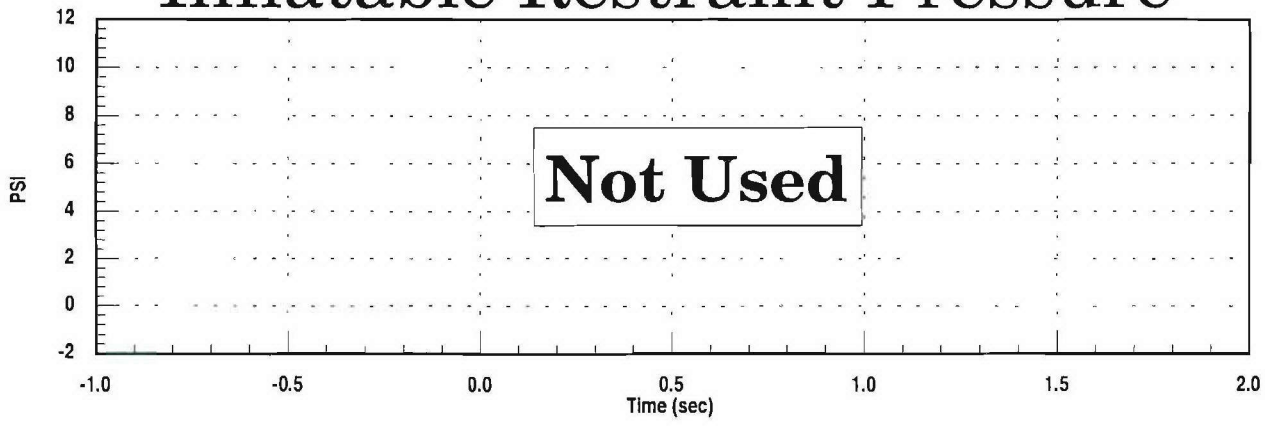
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

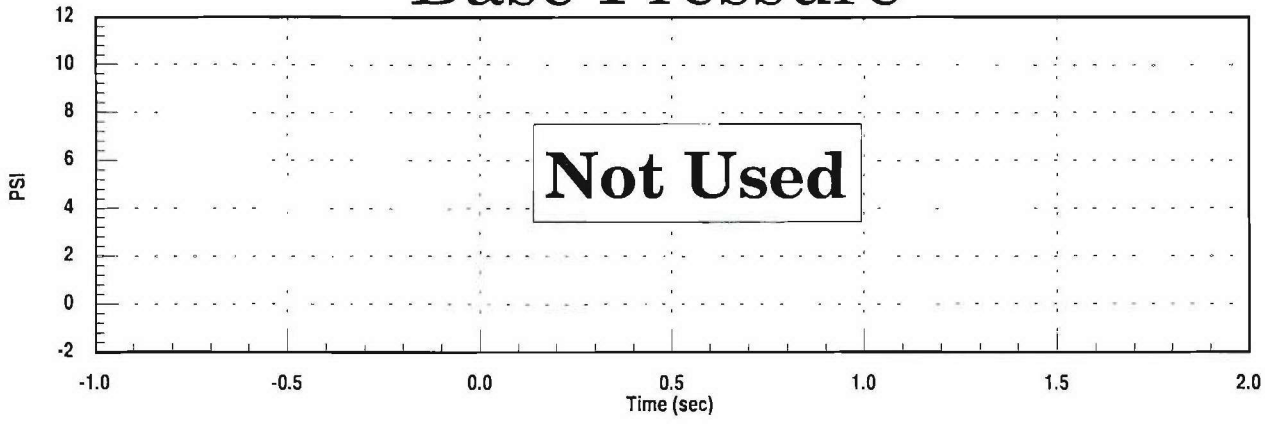
Main Rake Pressure



Inflatable Restraint Pressure



Base Pressure

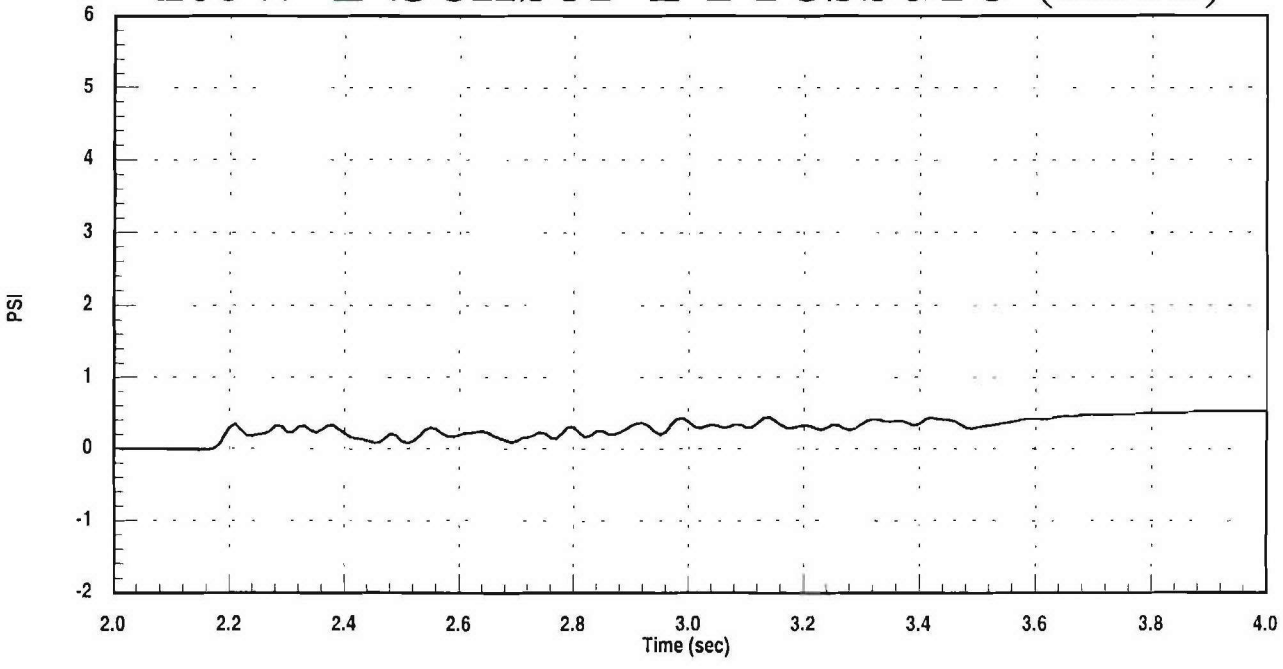


E-34

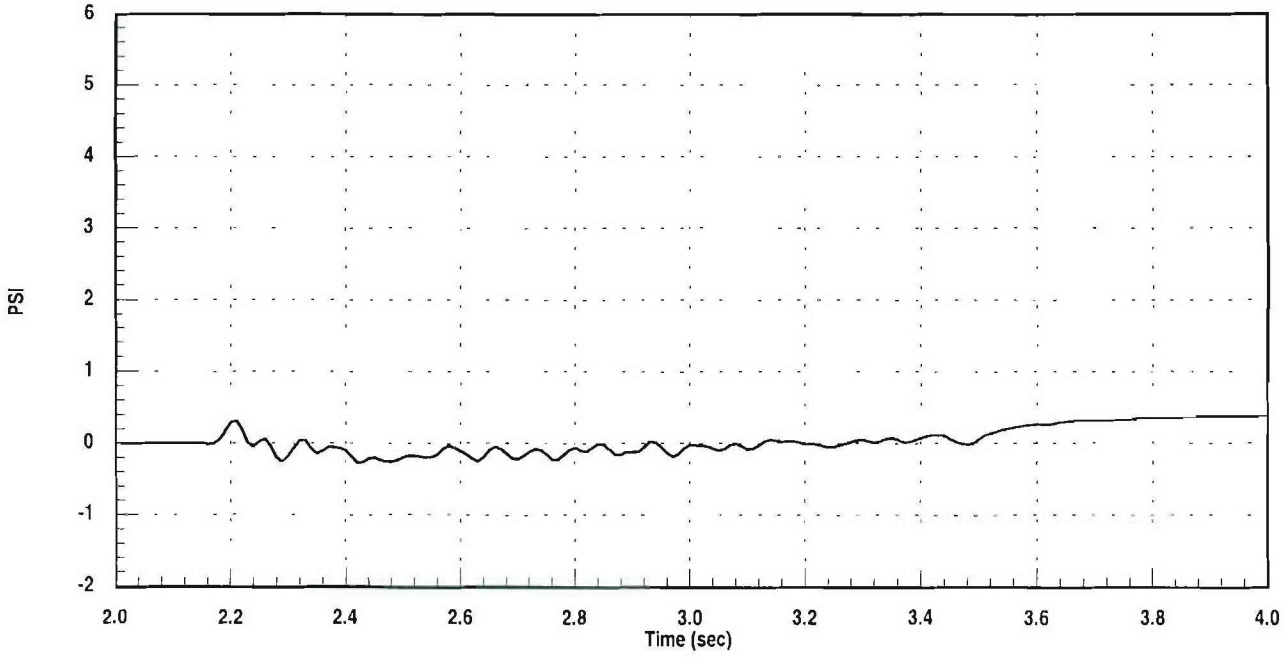
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



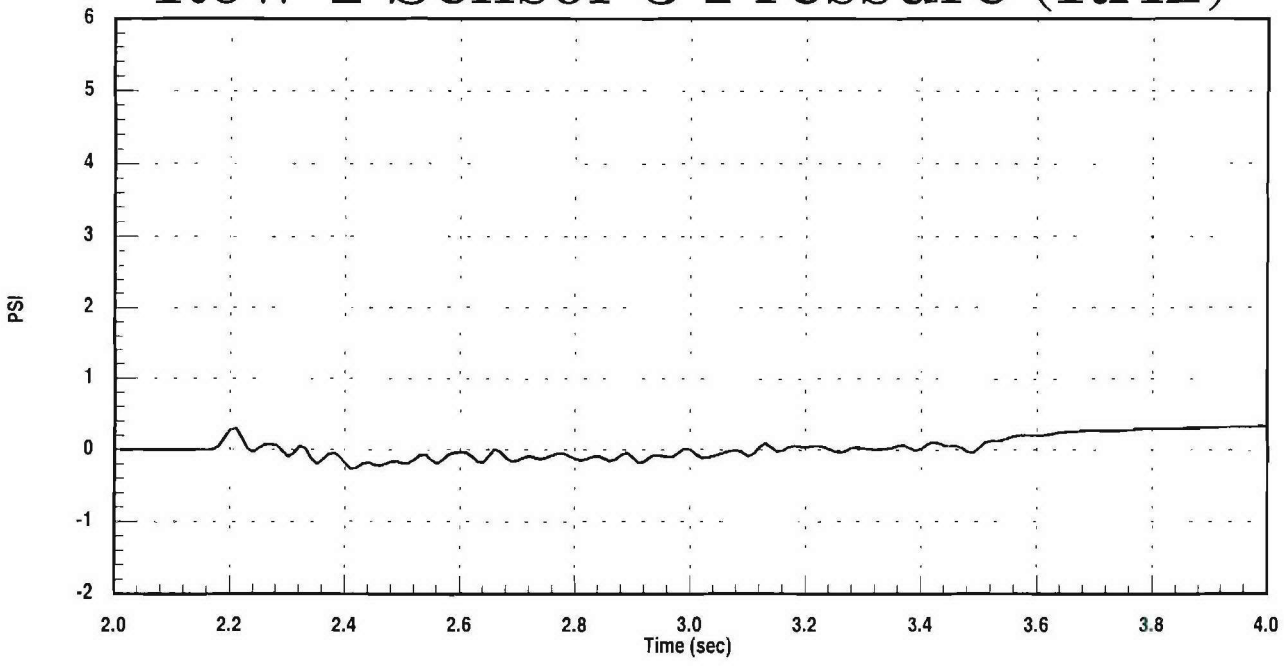
Row 1 Sensor 2 Pressure (LA2)



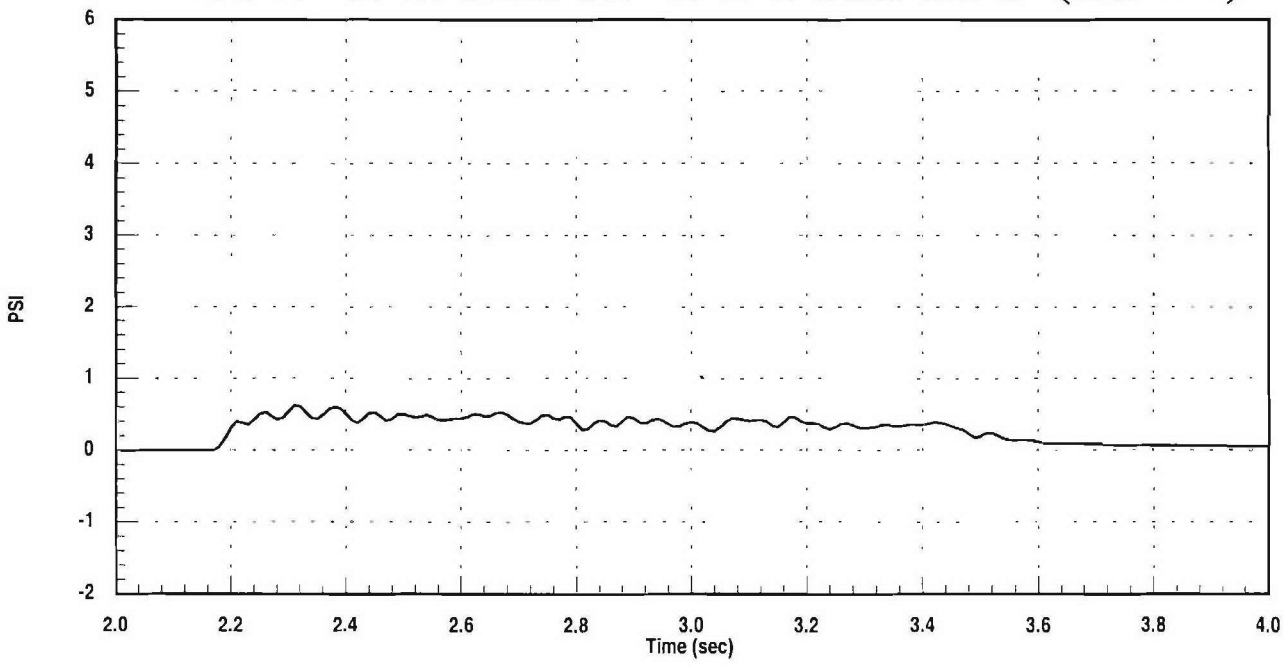
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



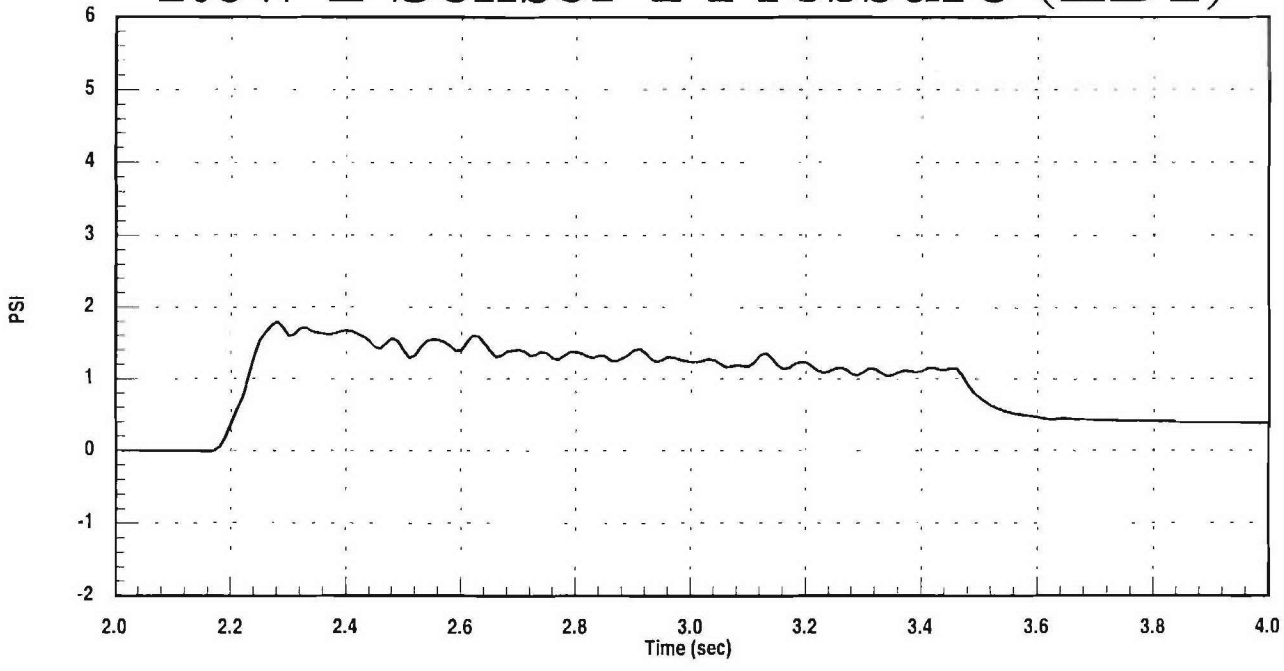
Row 1 Sensor 4 Pressure (RA1)



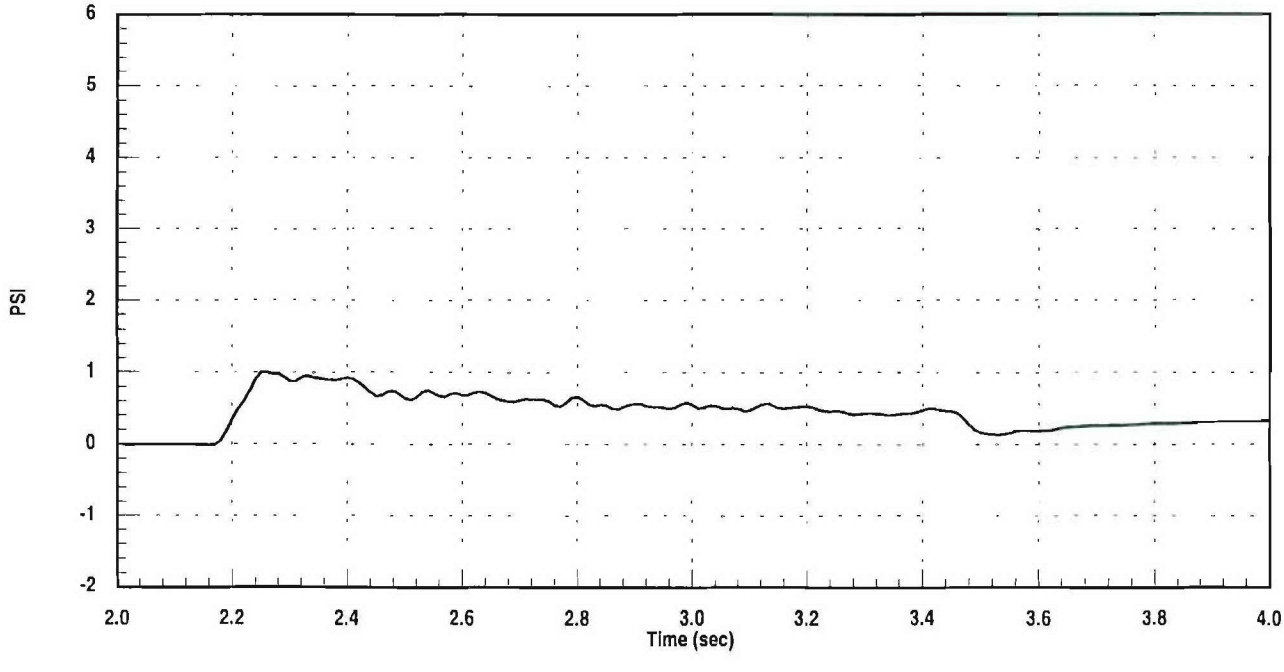
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



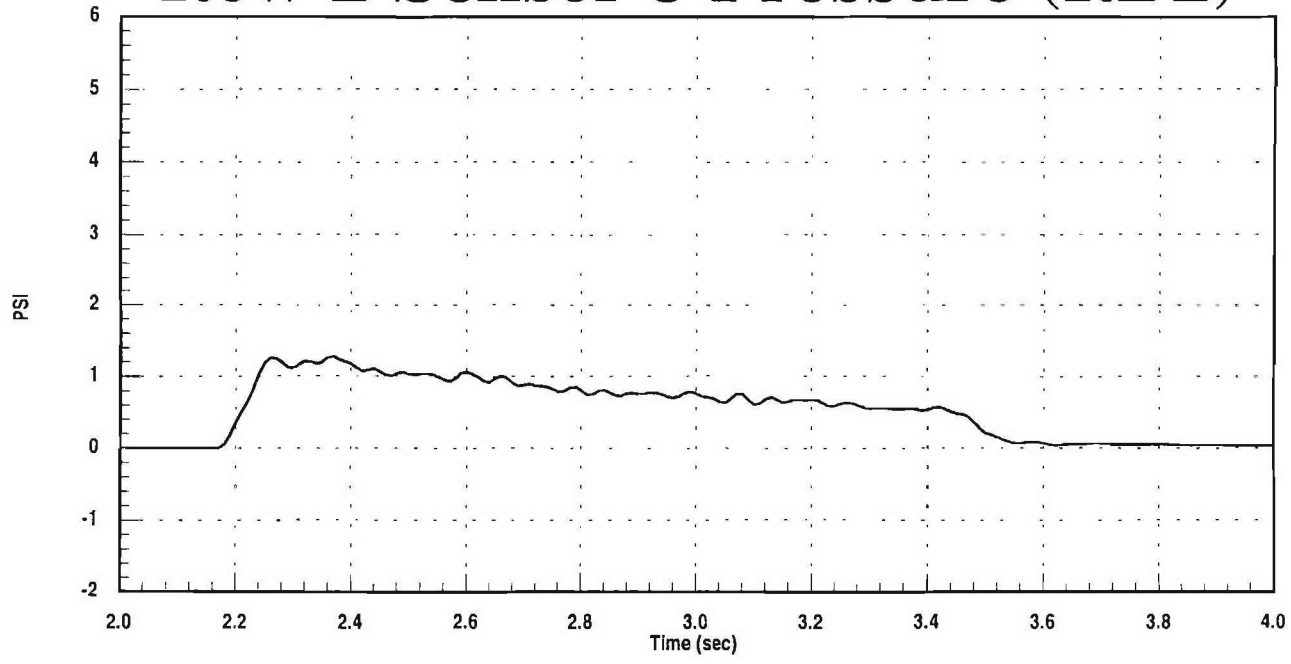
Row 2 Sensor 2 Pressure (LB2)



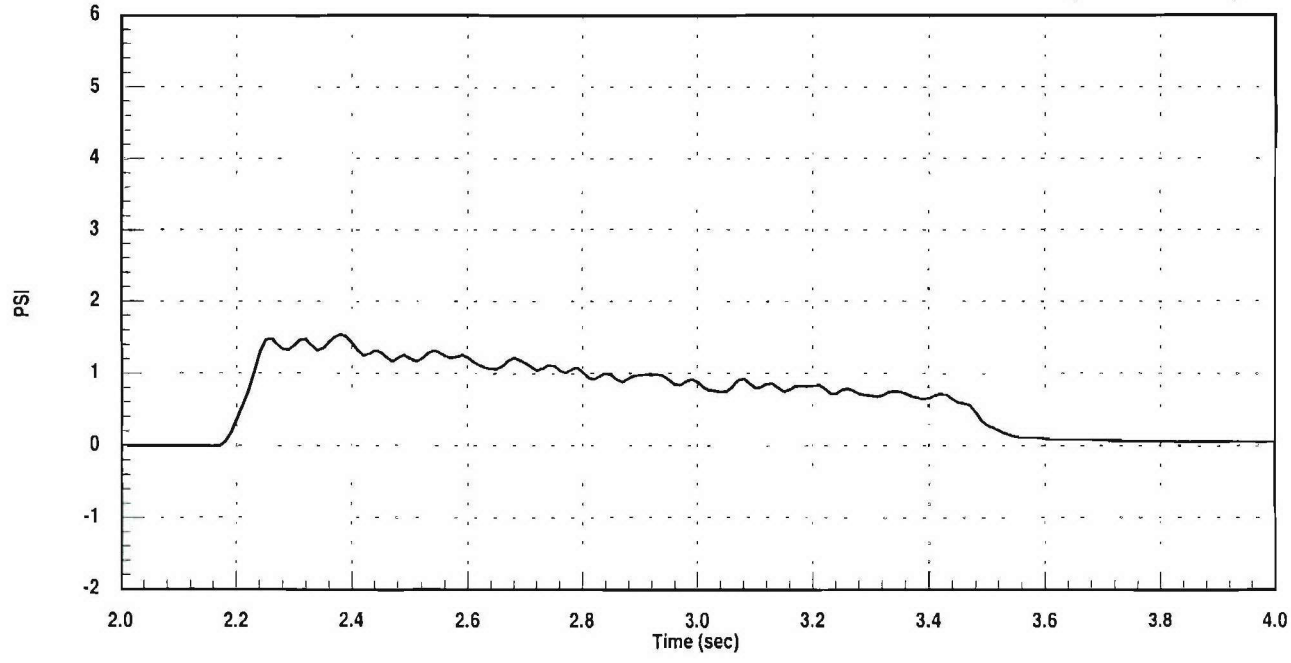
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



Row 2 Sensor 4 Pressure (RB1)

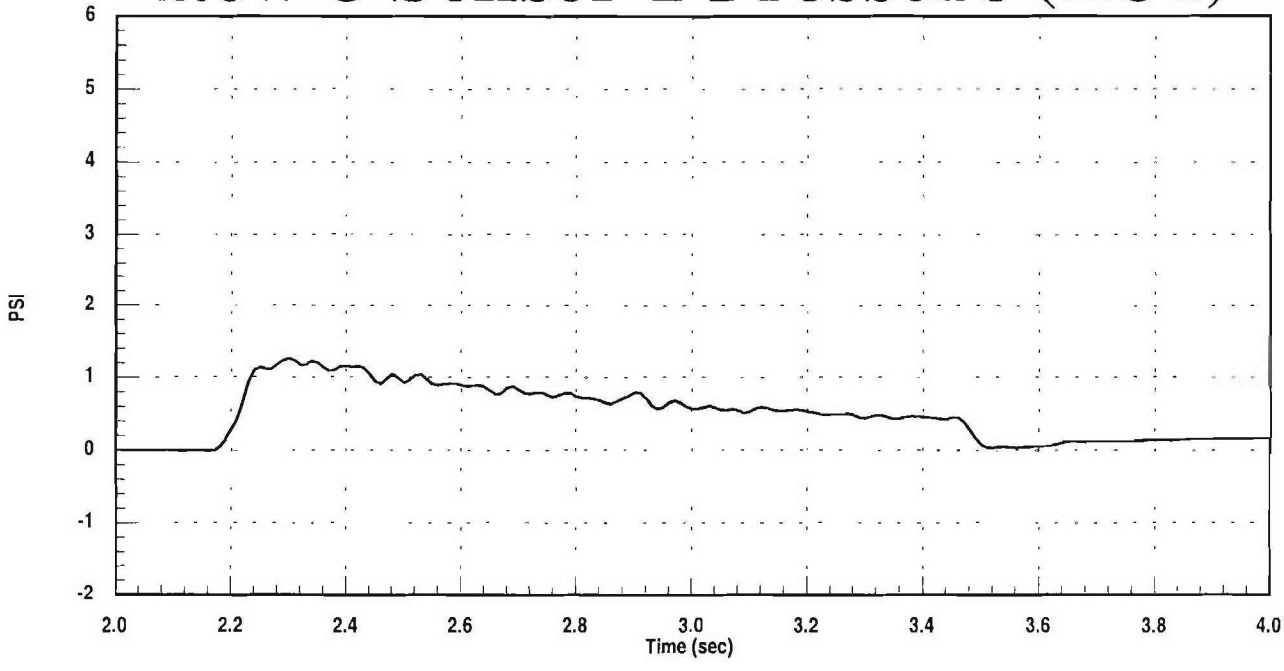


E-38

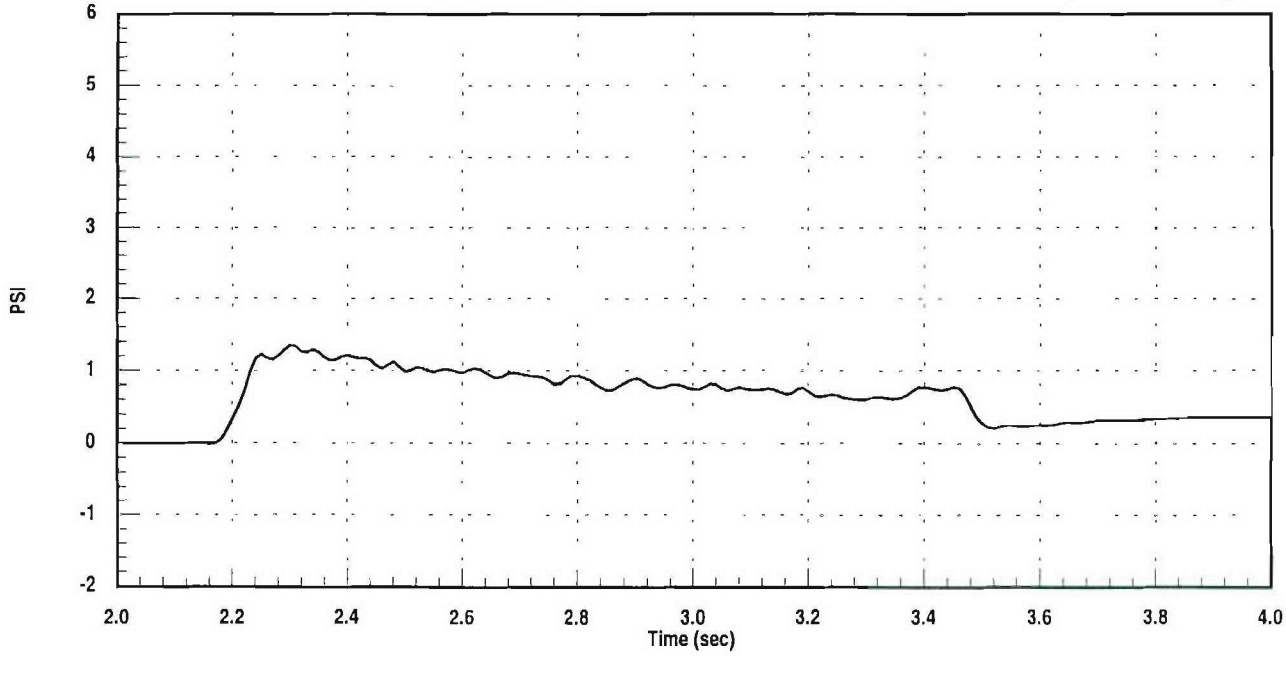
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



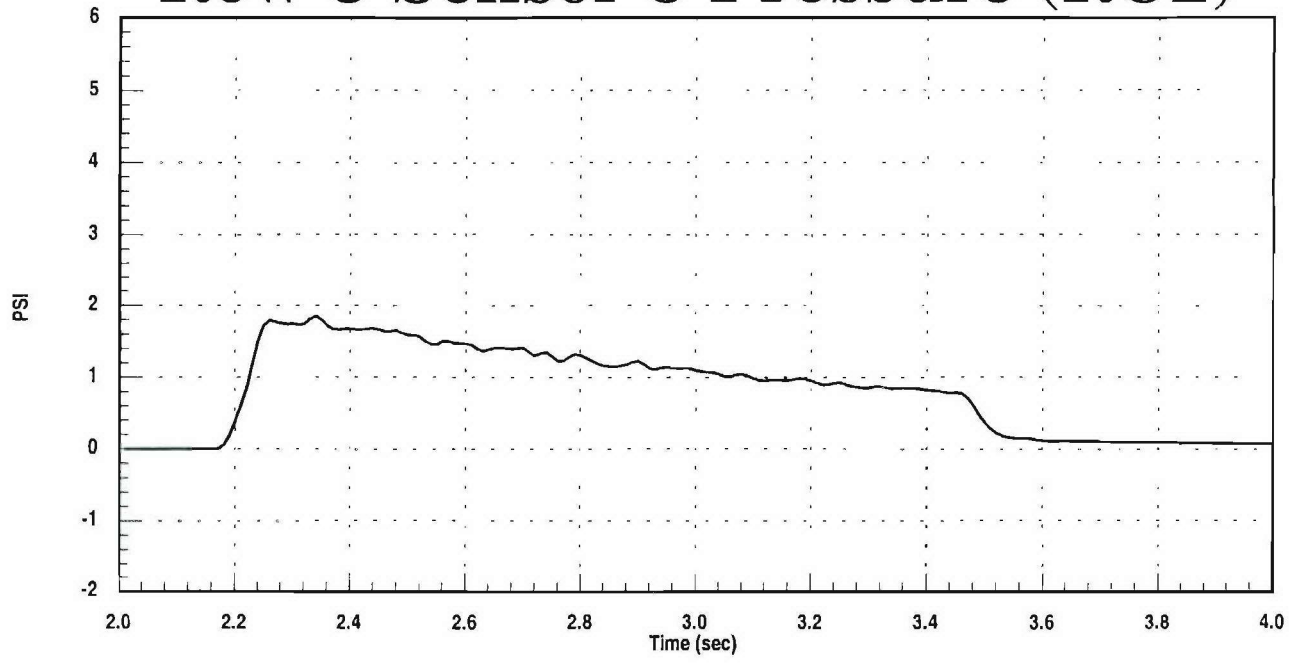
Row 3 Sensor 2 Pressure (LC2)



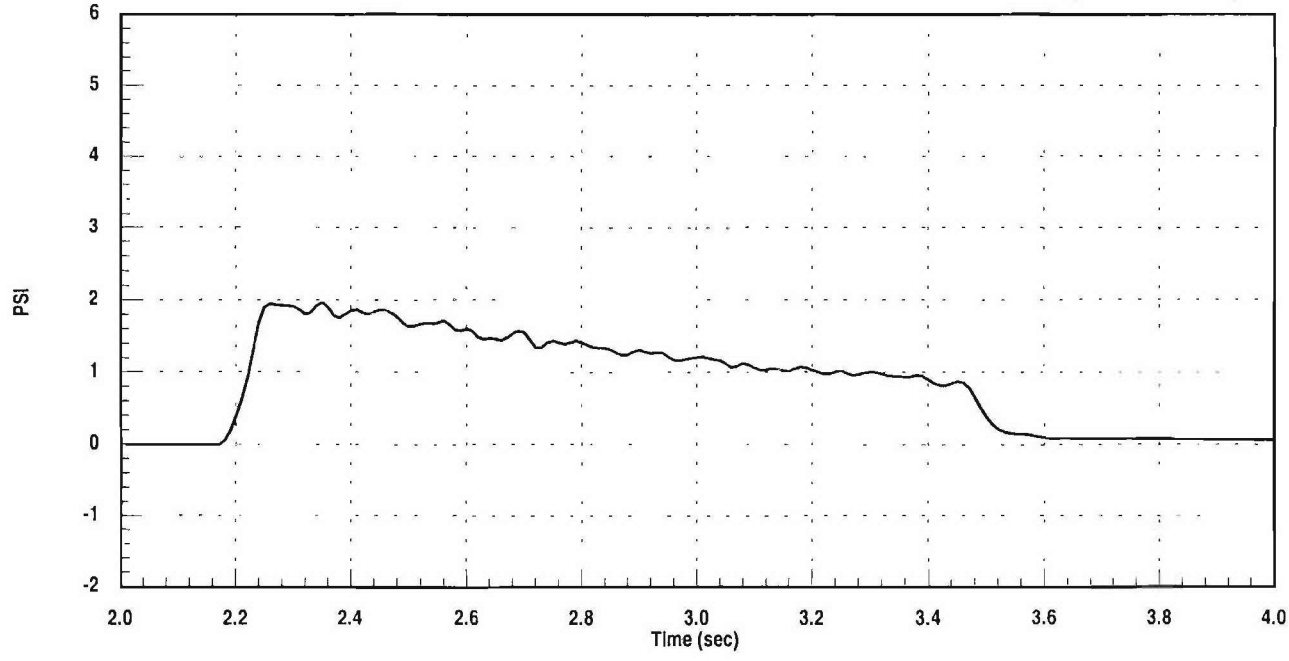
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



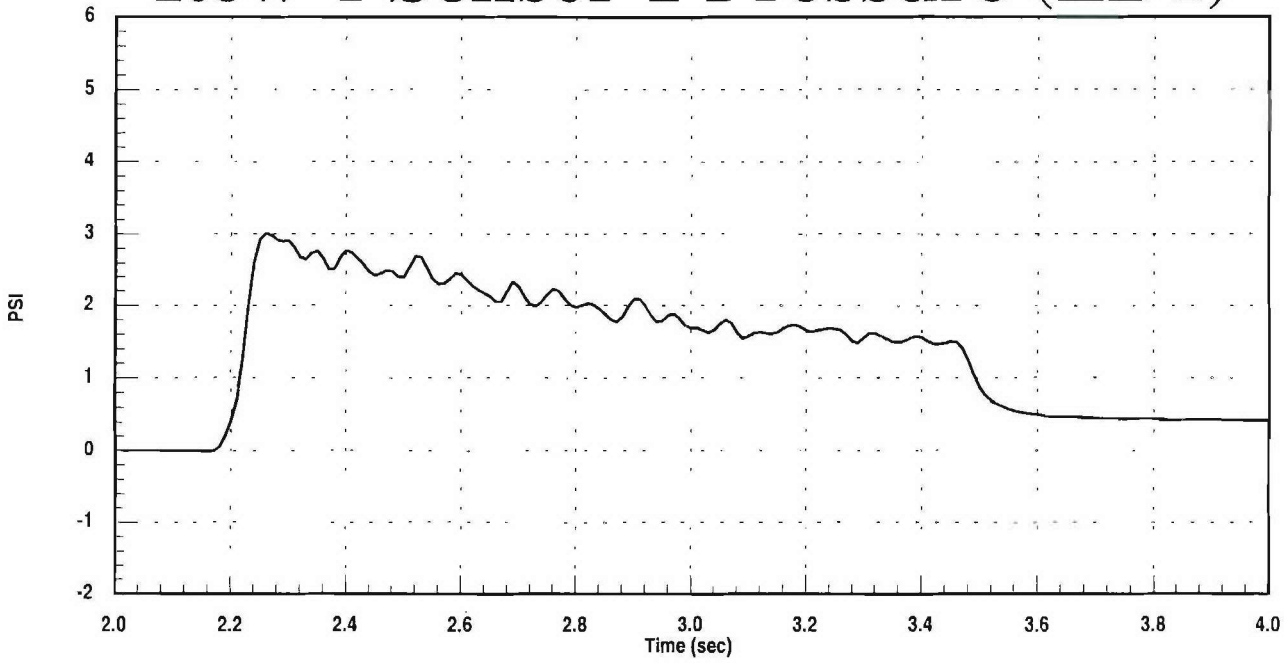
Row 3 Sensor 4 Pressure (RC1)



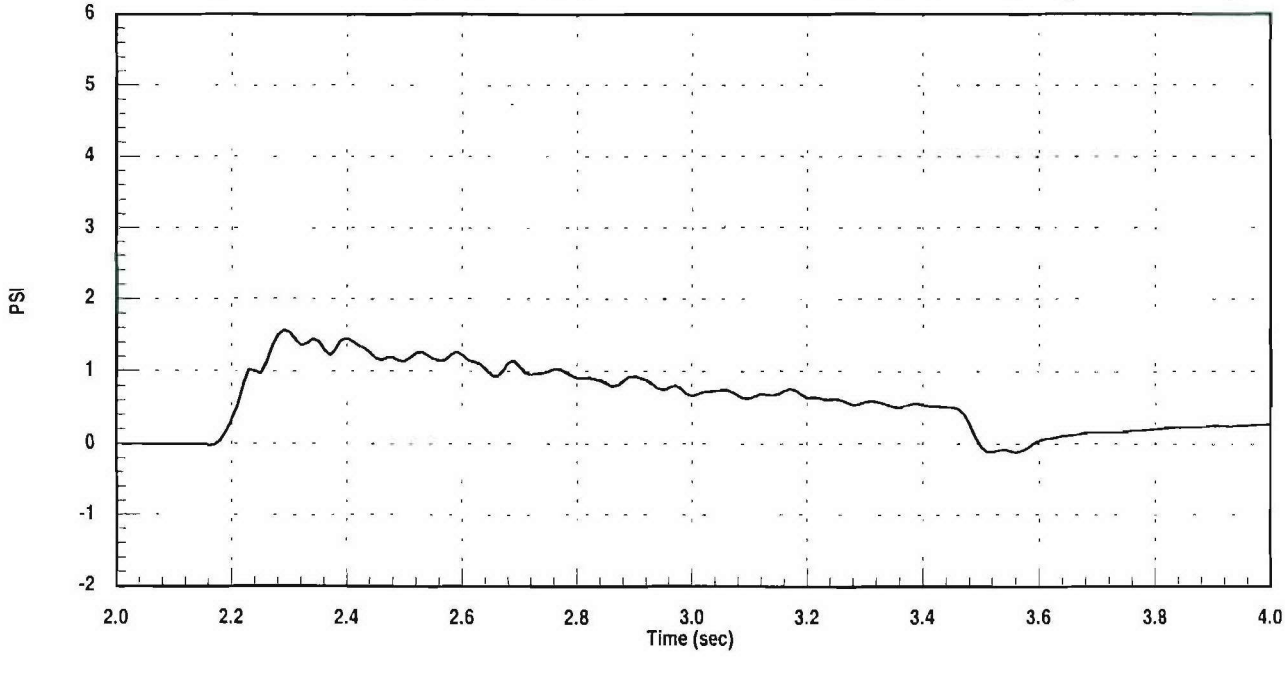
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



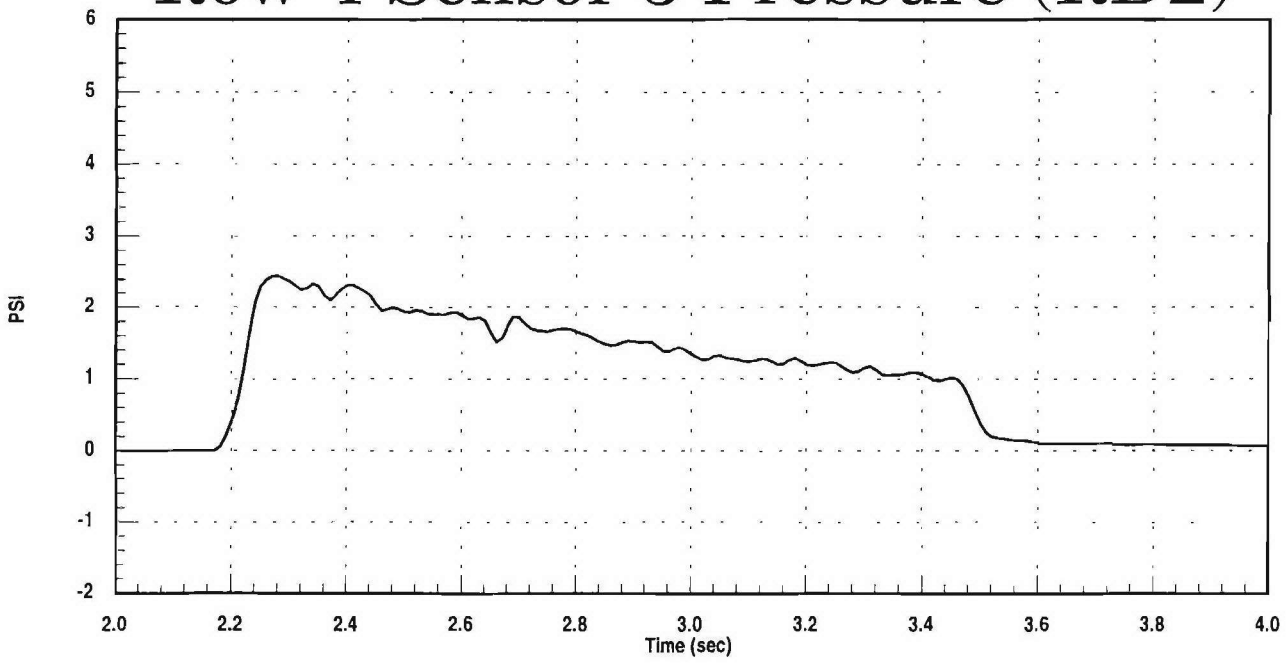
Row 4 Sensor 2 Pressure (LD2)



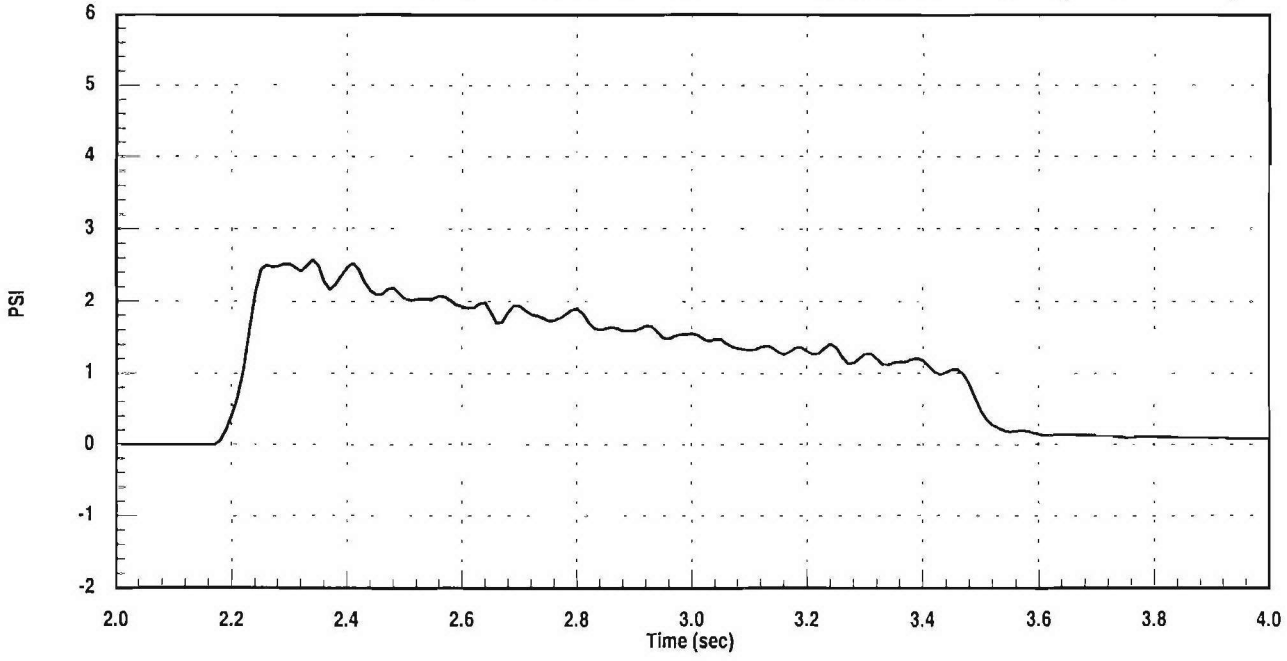
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



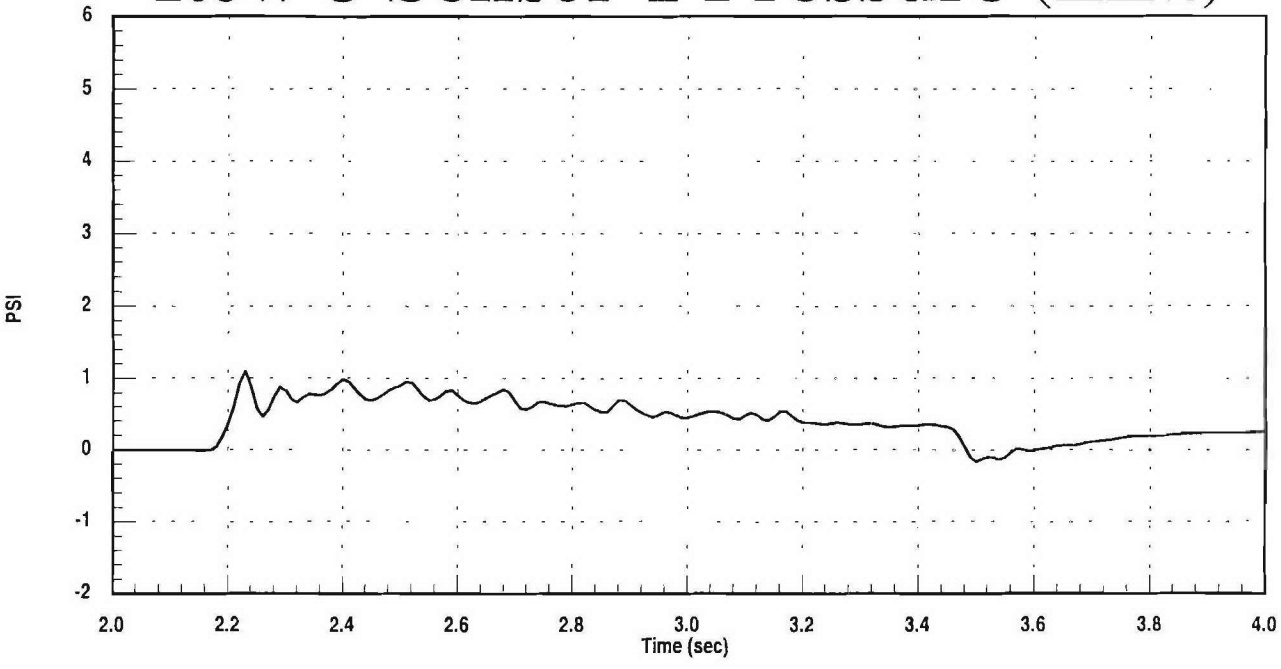
Row 4 Sensor 4 Pressure (RD1)



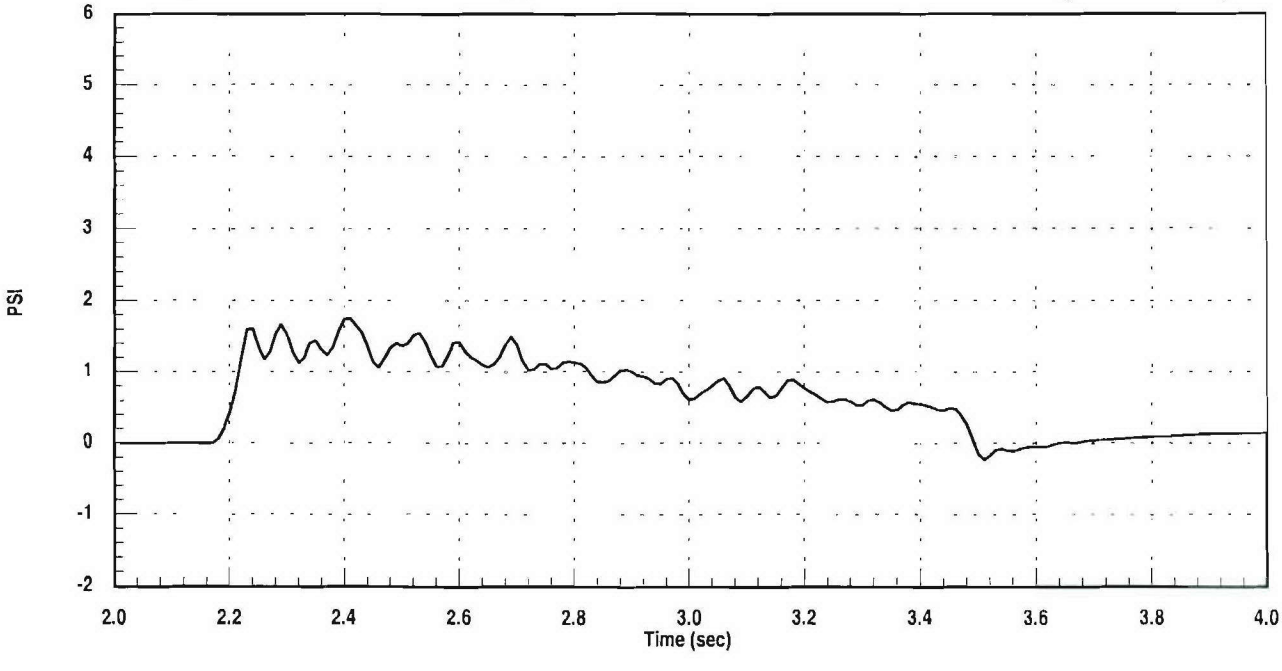
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



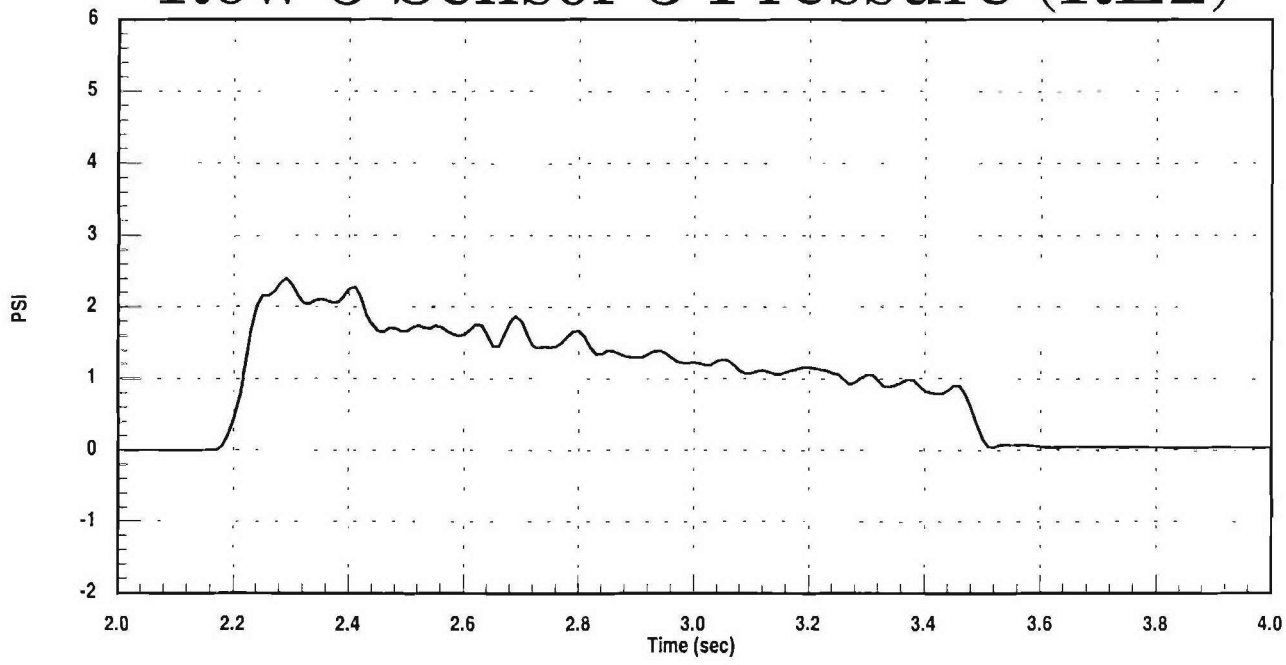
Row 5 Sensor 2 Pressure (LE2)



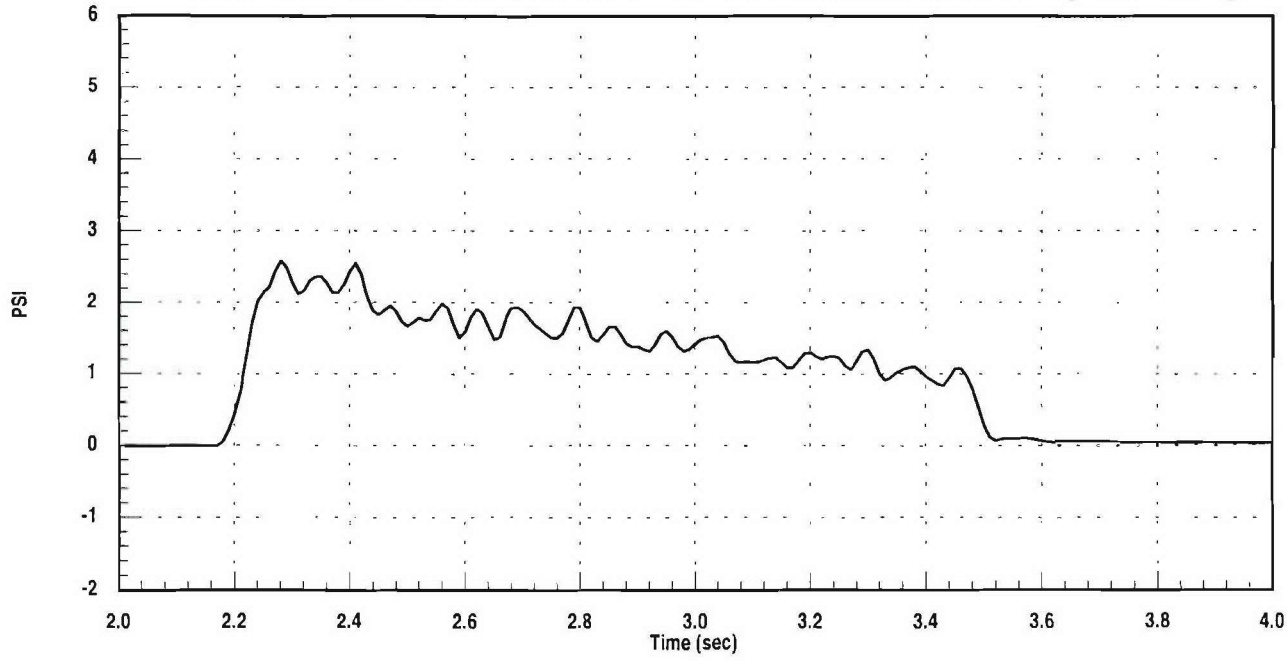
WD4, 375 KEAS

T-38 Mass and Sail / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



WD5, 375 KEAS

Post / Torso Rake

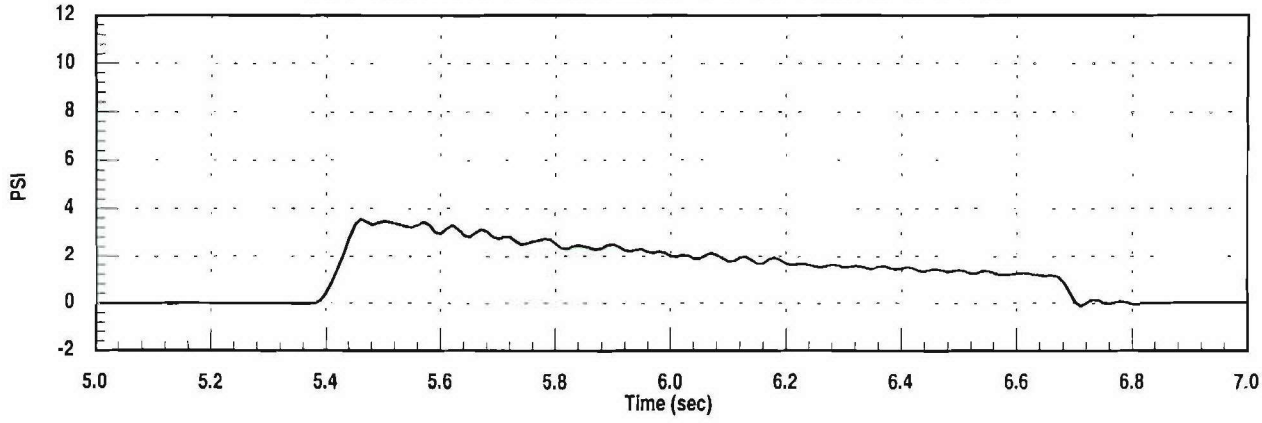
Processed Data

Main Rake Pressure	E-46
Row 1 Sensor 1 & 2 Pressures	E-47
Row 1 Sensor 3 & 4 Pressures	E-48
Row 2 Sensor 1 & 2 Pressures	E-49
Row 2 Sensor 3 & 4 Pressures	E-50
Row 3 Sensor 1 & 2 Pressures	E-51
Row 3 Sensor 3 & 4 Pressures	E-52
Row 4 Sensor 1 & 2 Pressures	E-53
Row 4 Sensor 3 & 4 Pressures	E-54
Row 5 Sensor 1 & 2 Pressures	E-55
Row 5 Sensor 3 & 4 Pressures	E-56

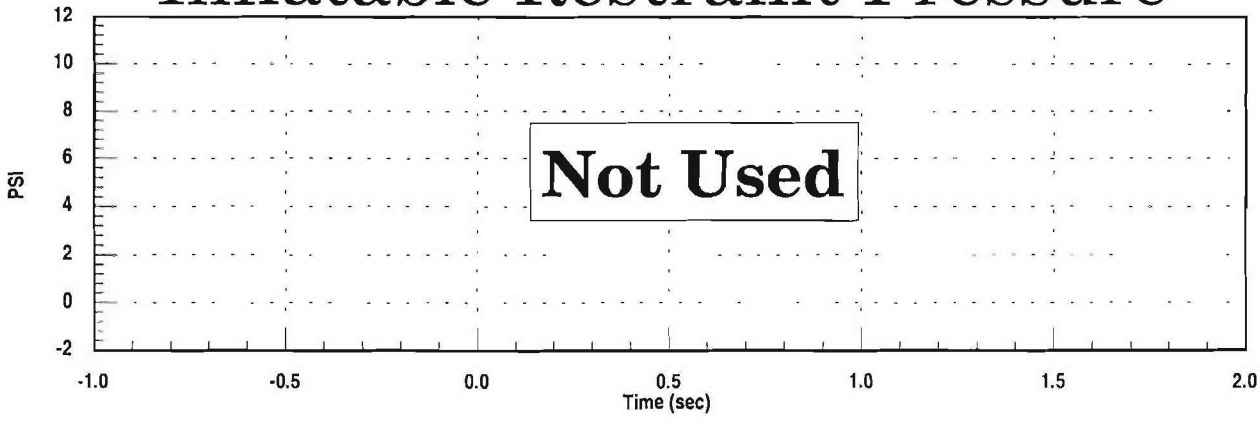
WD5, 375 KEAS

Post / Torso Rake

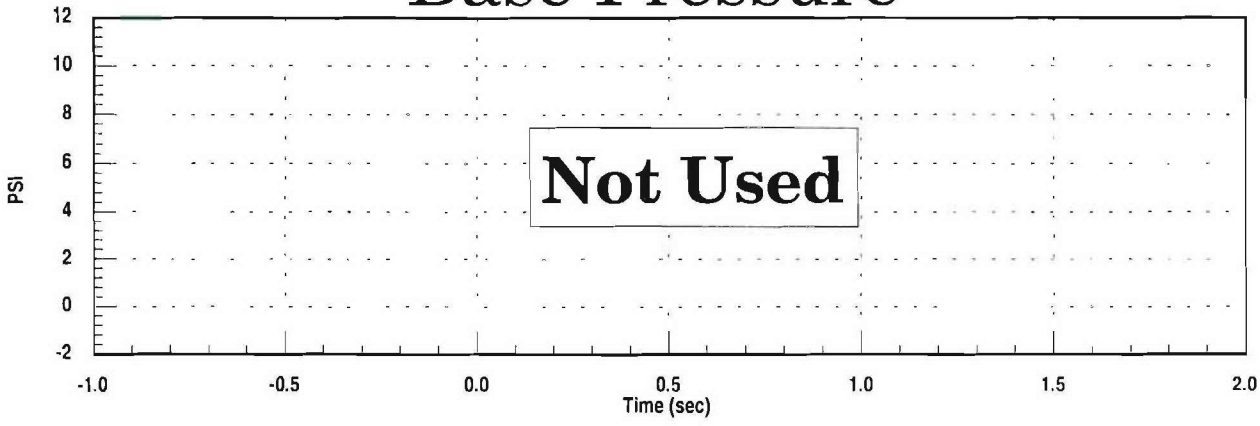
Main Rake Pressure



Inflatable Restraint Pressure



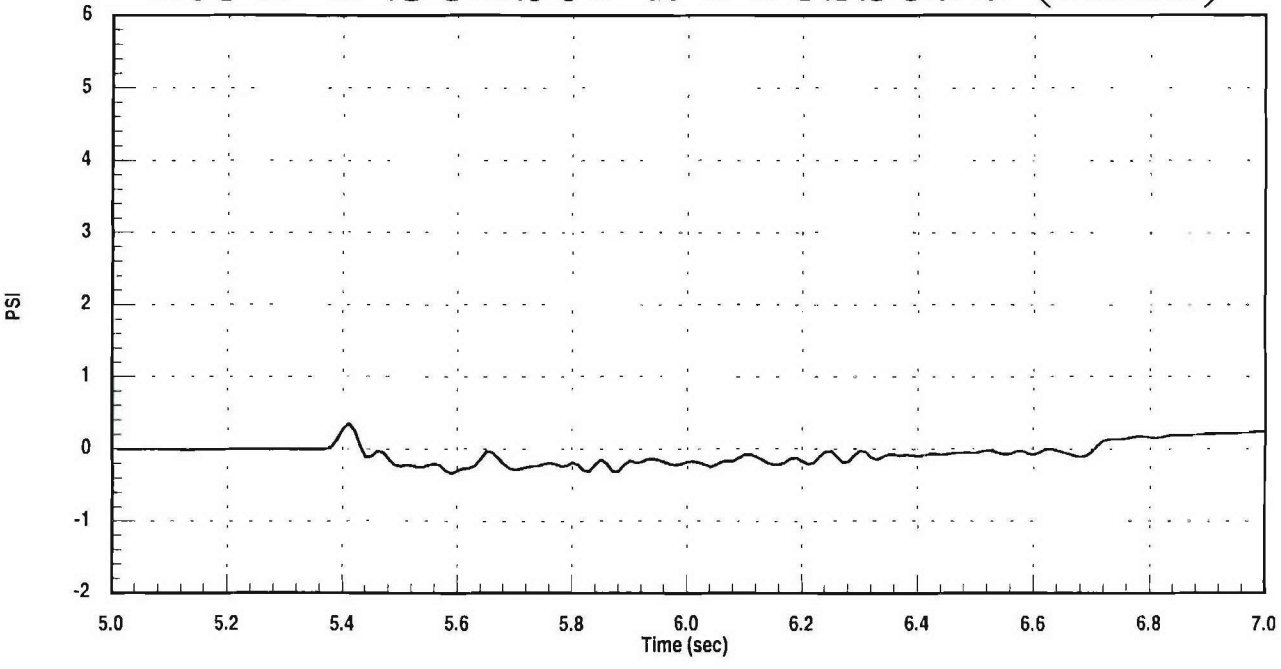
Base Pressure



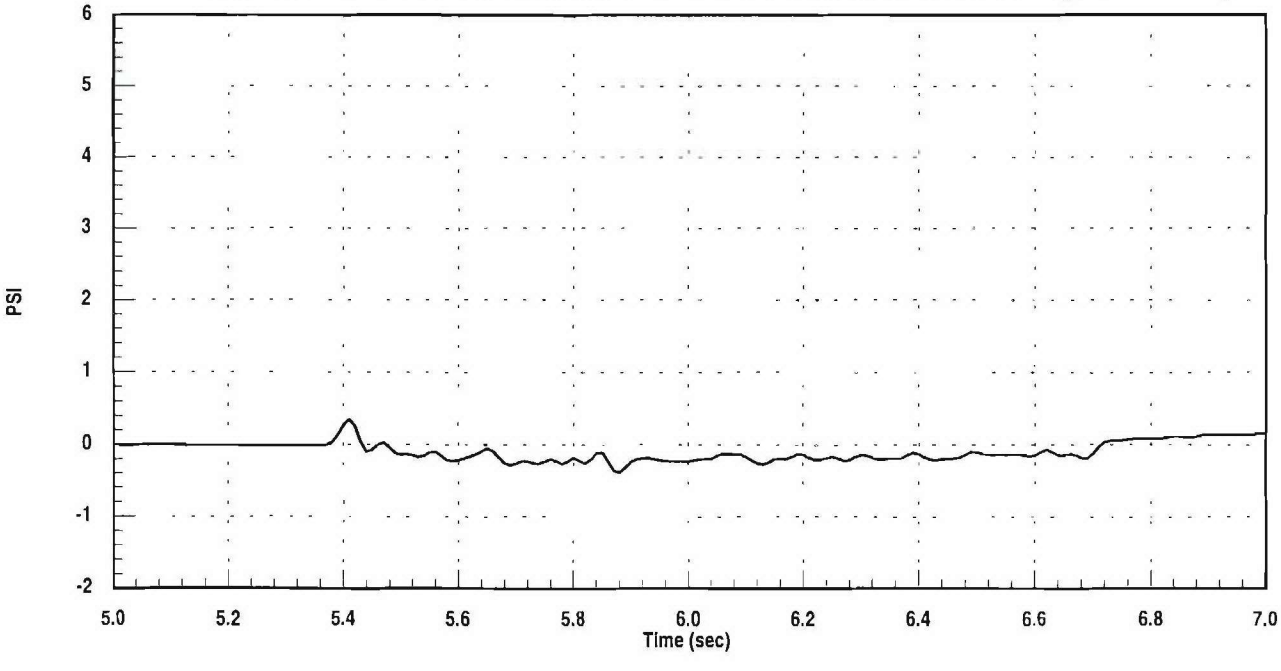
WD5, 375 KEAS

Post / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



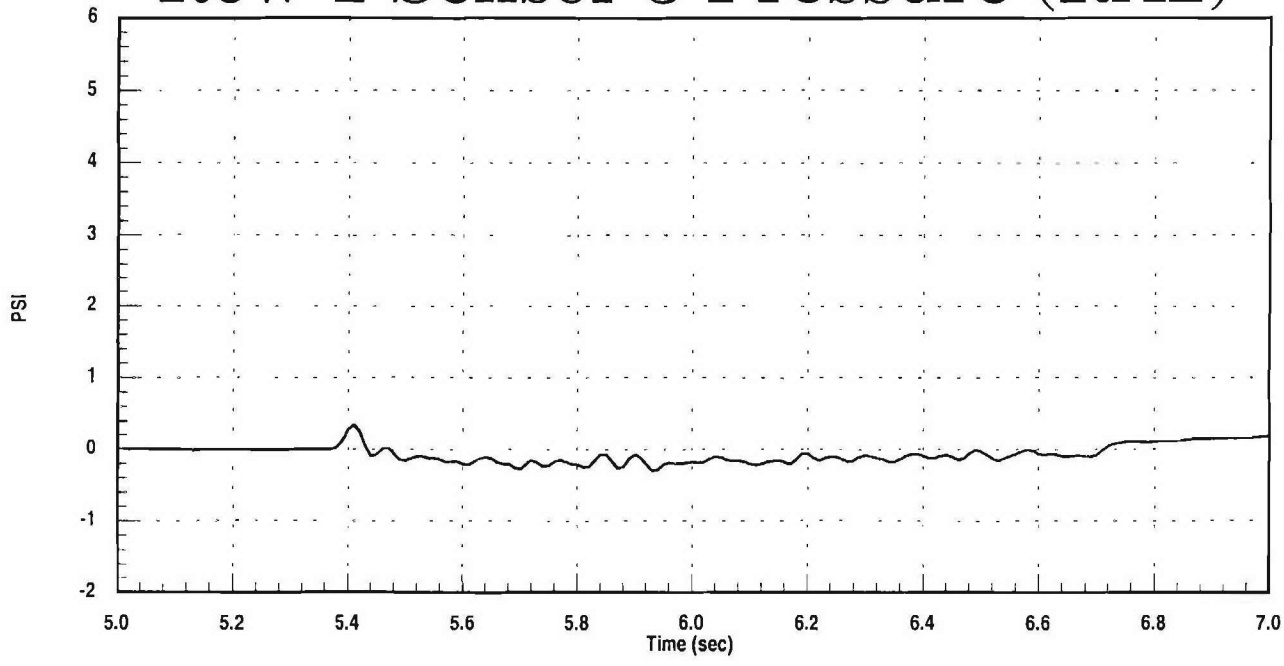
Row 1 Sensor 2 Pressure (LA2)



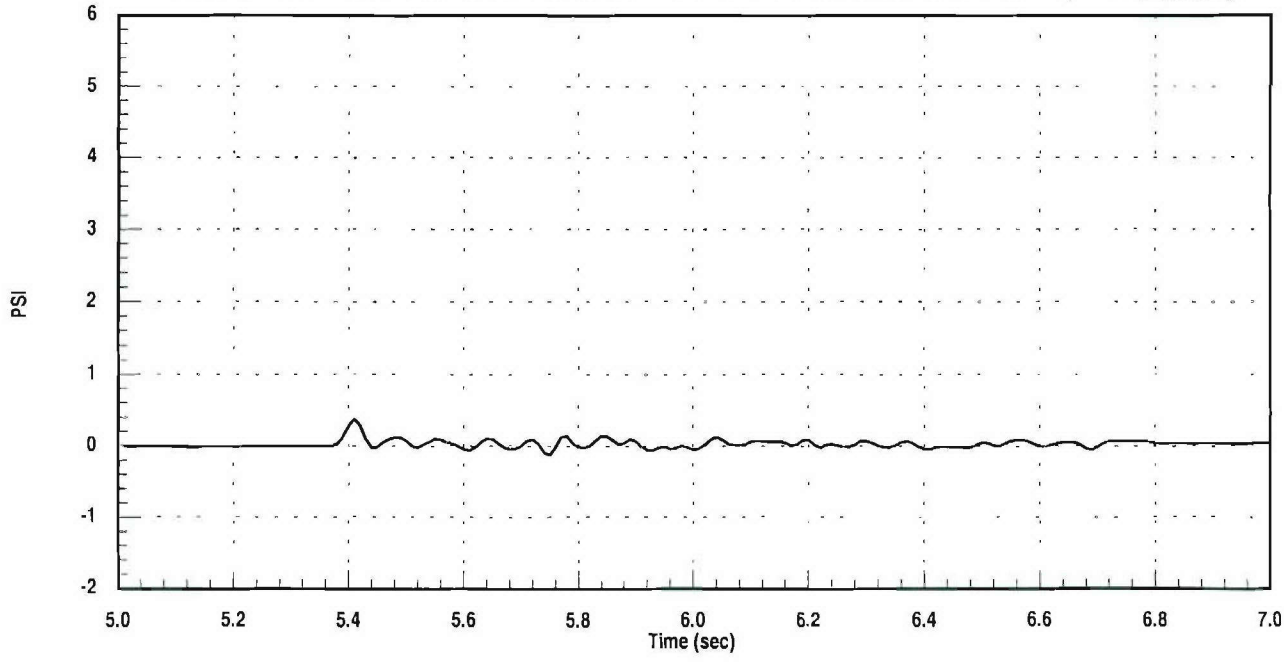
WD5, 375 KEAS

Post / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



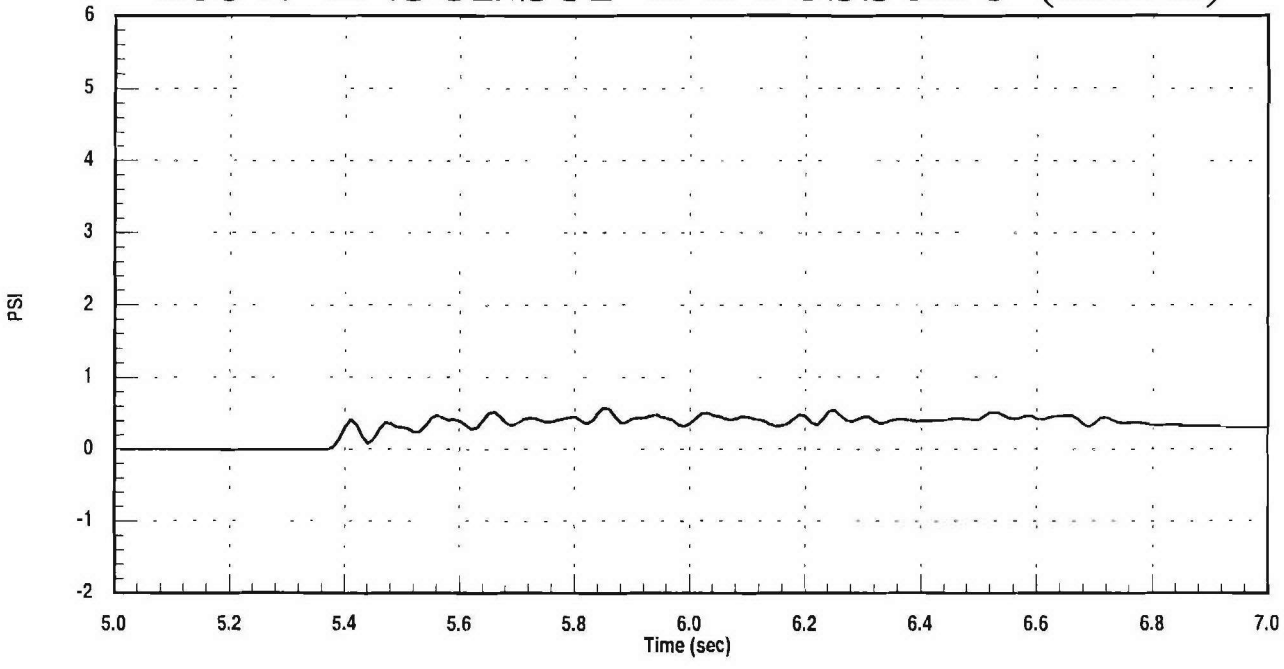
Row 1 Sensor 4 Pressure (RA1)



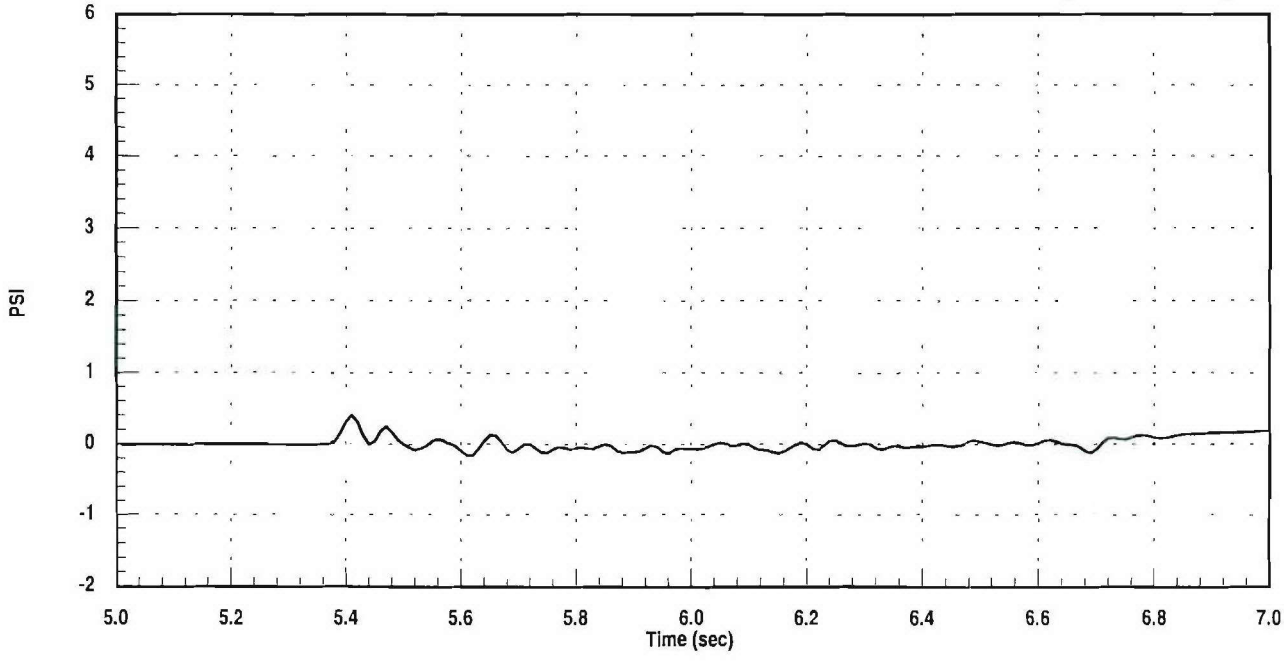
WD5, 375 KEAS

Post / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



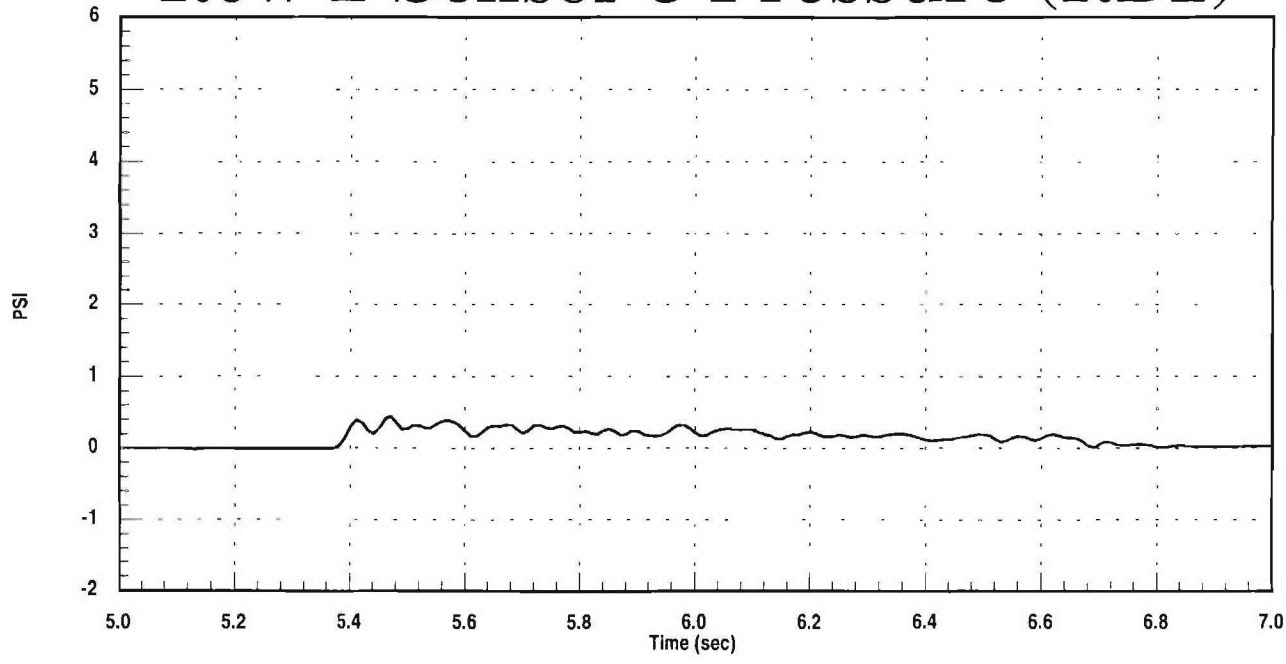
Row 2 Sensor 2 Pressure (LB2)



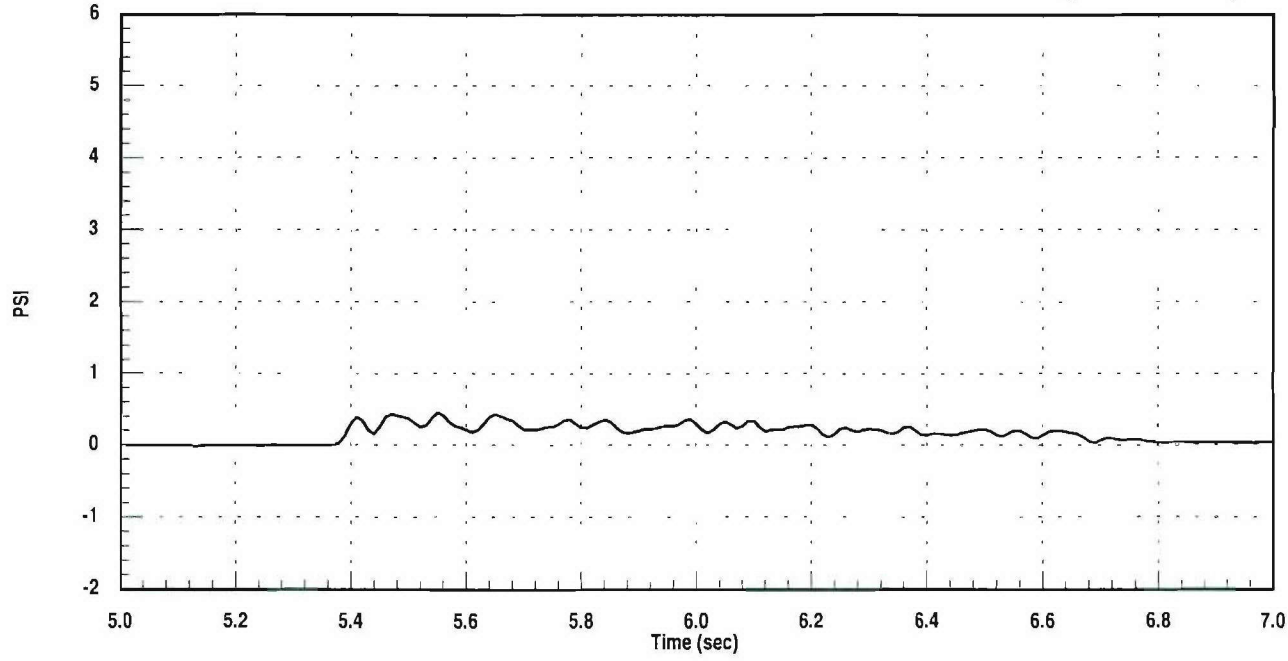
WD5, 375 KEAS

Post / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



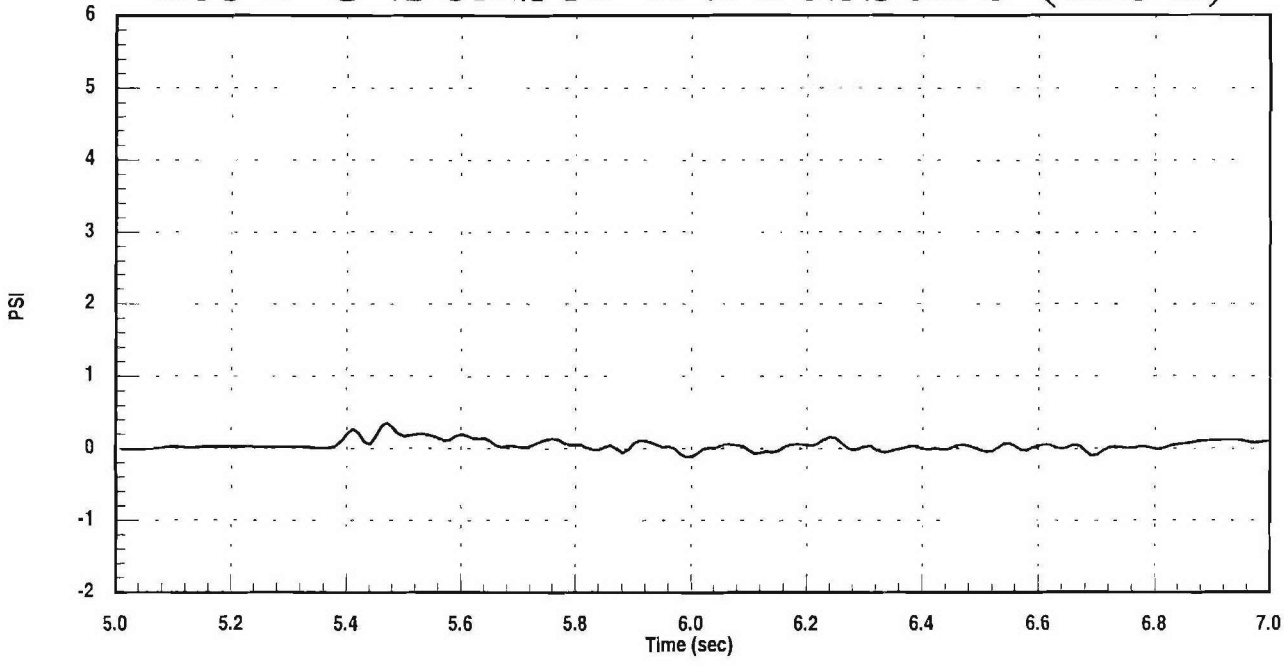
Row 2 Sensor 4 Pressure (RB1)



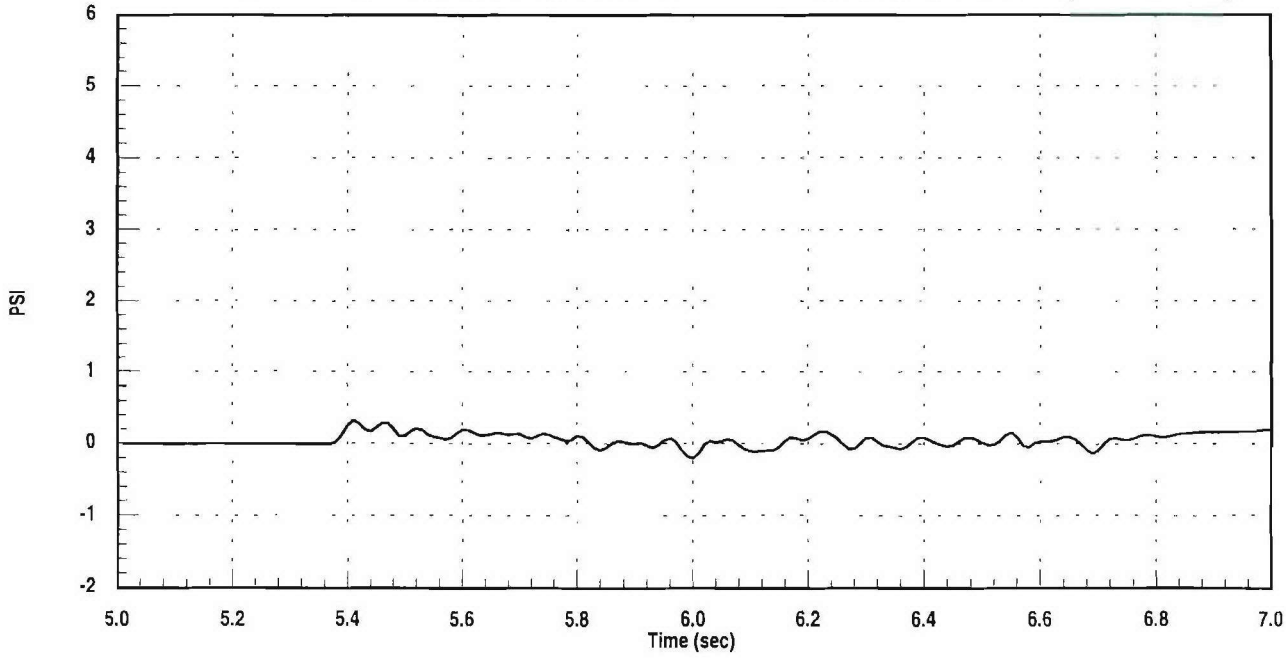
WD5, 375 KEAS

Post / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



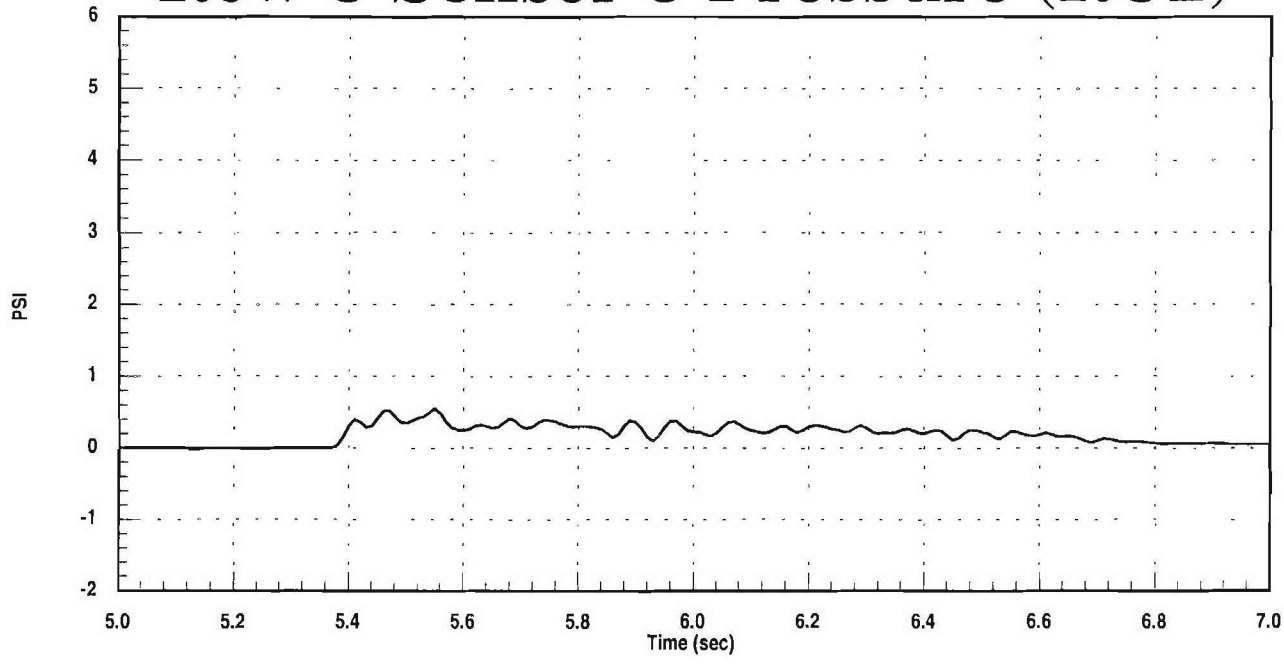
Row 3 Sensor 2 Pressure (LC2)



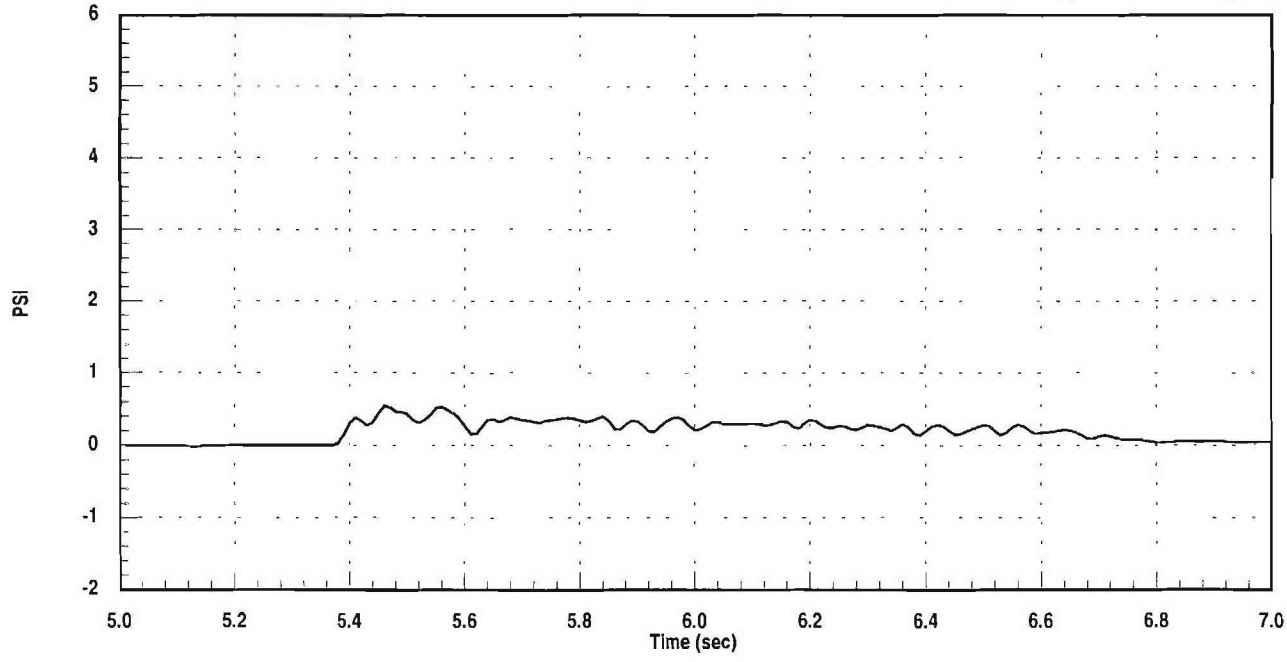
WD5, 375 KEAS

Post / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



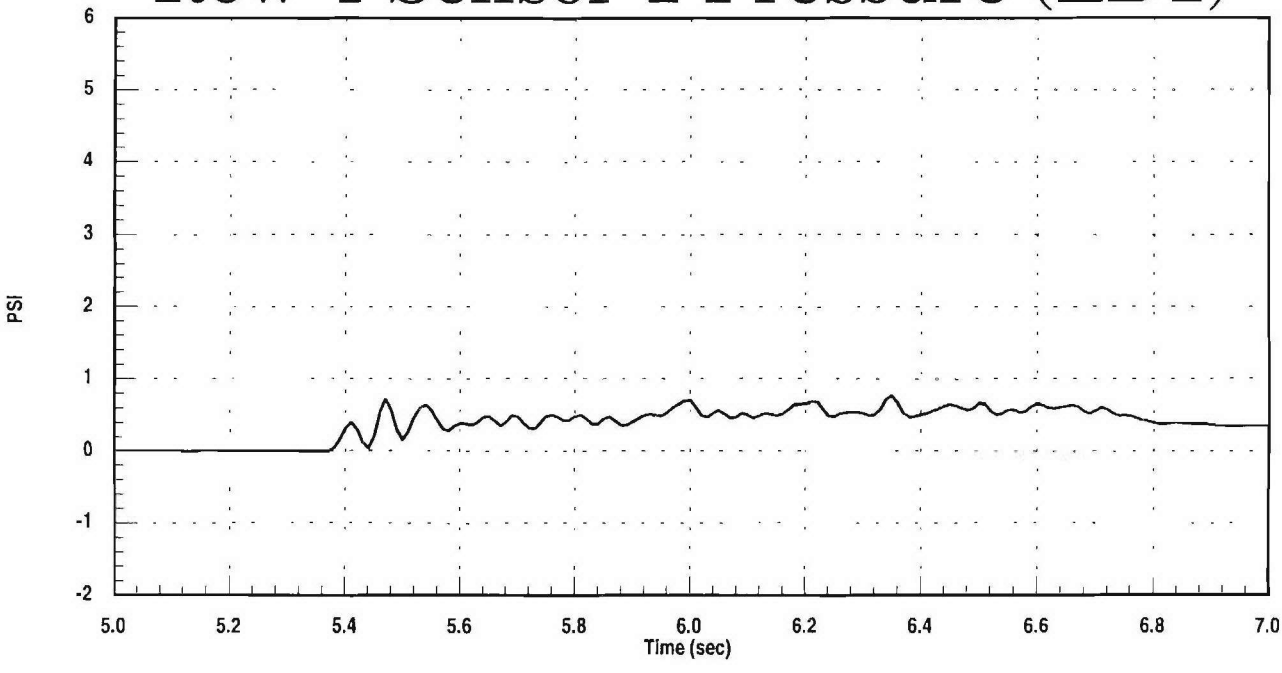
Row 3 Sensor 4 Pressure (RC1)



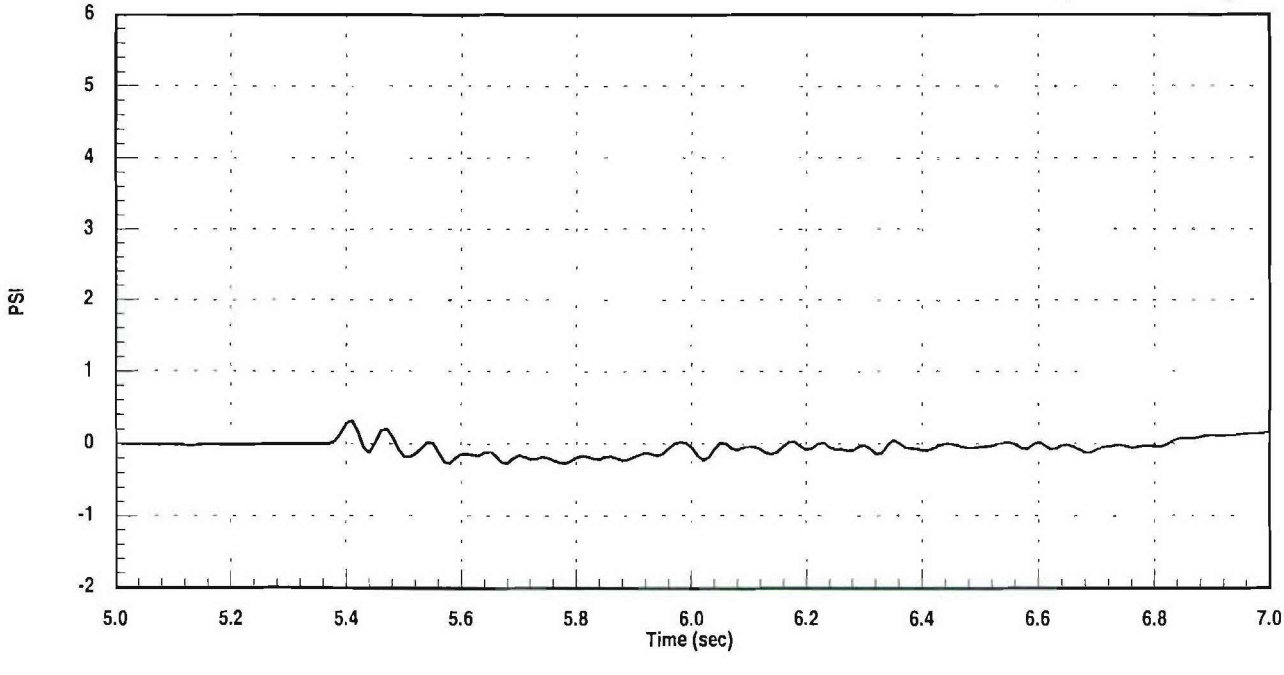
WD5, 375 KEAS

Post / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



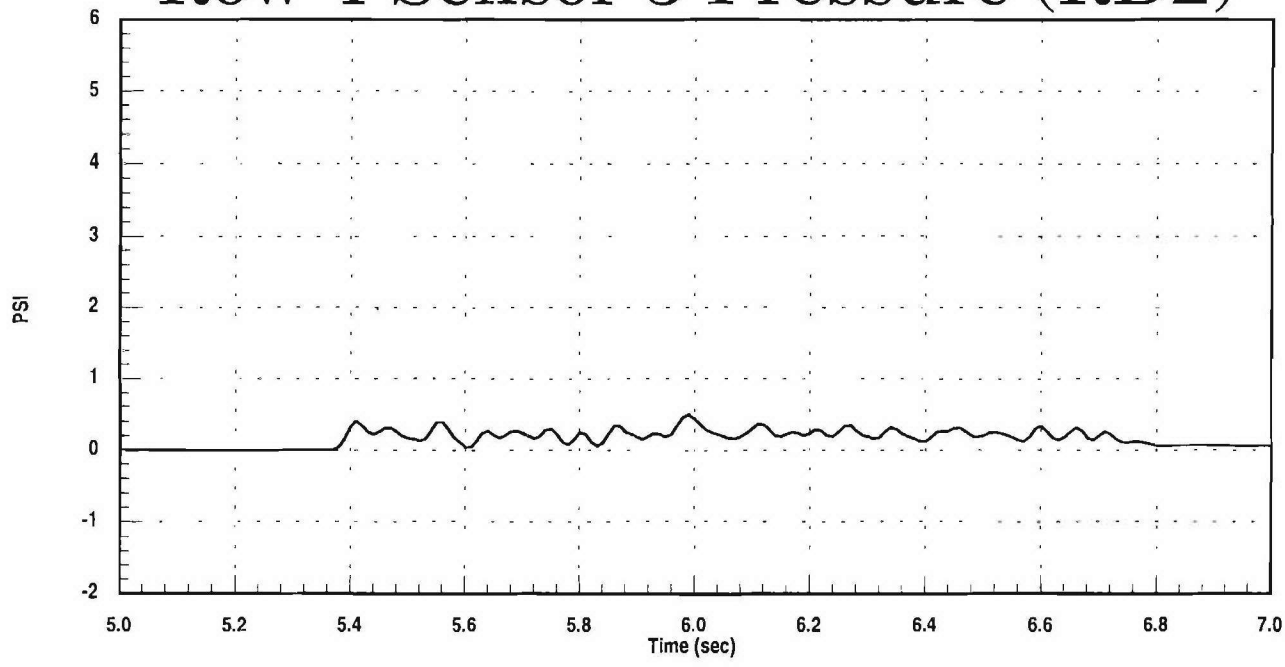
Row 4 Sensor 2 Pressure (LD2)



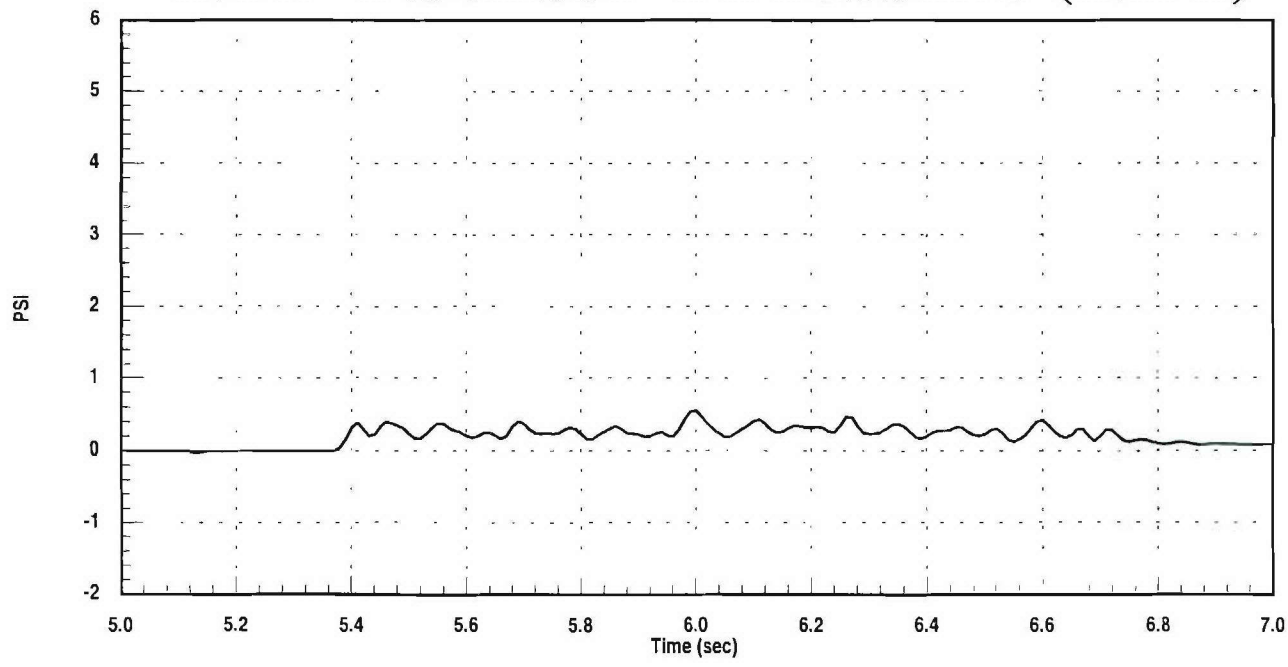
WD5, 375 KEAS

Post / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



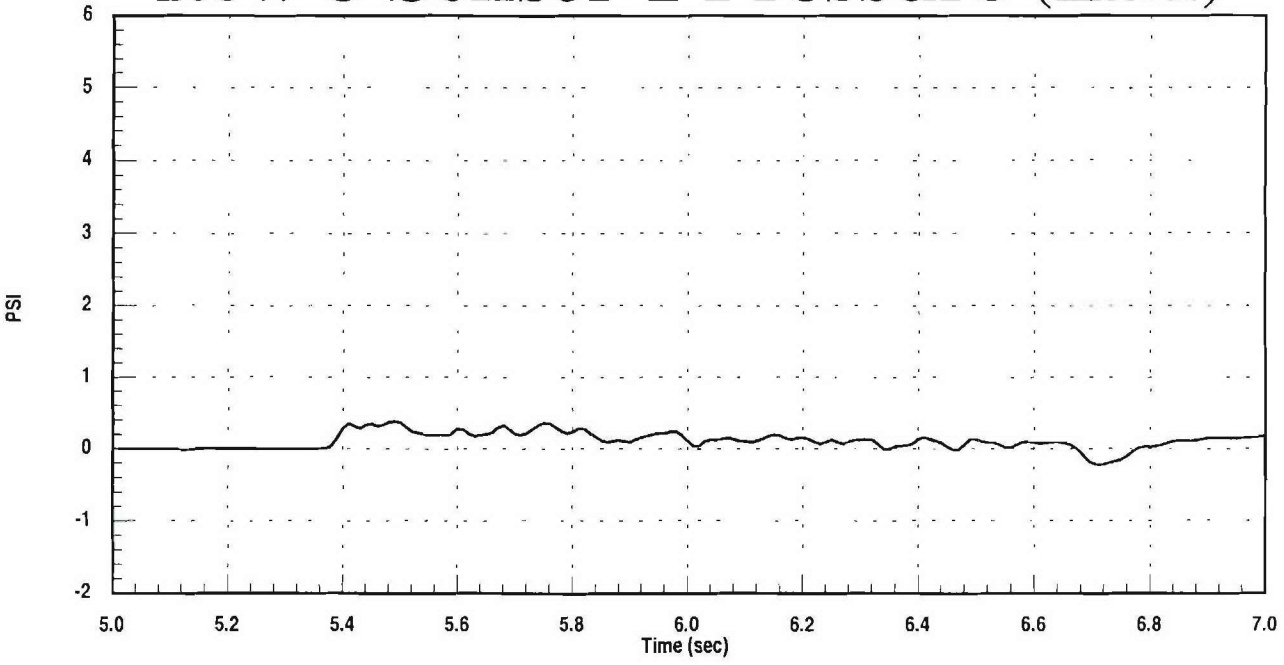
Row 4 Sensor 4 Pressure (RD1)



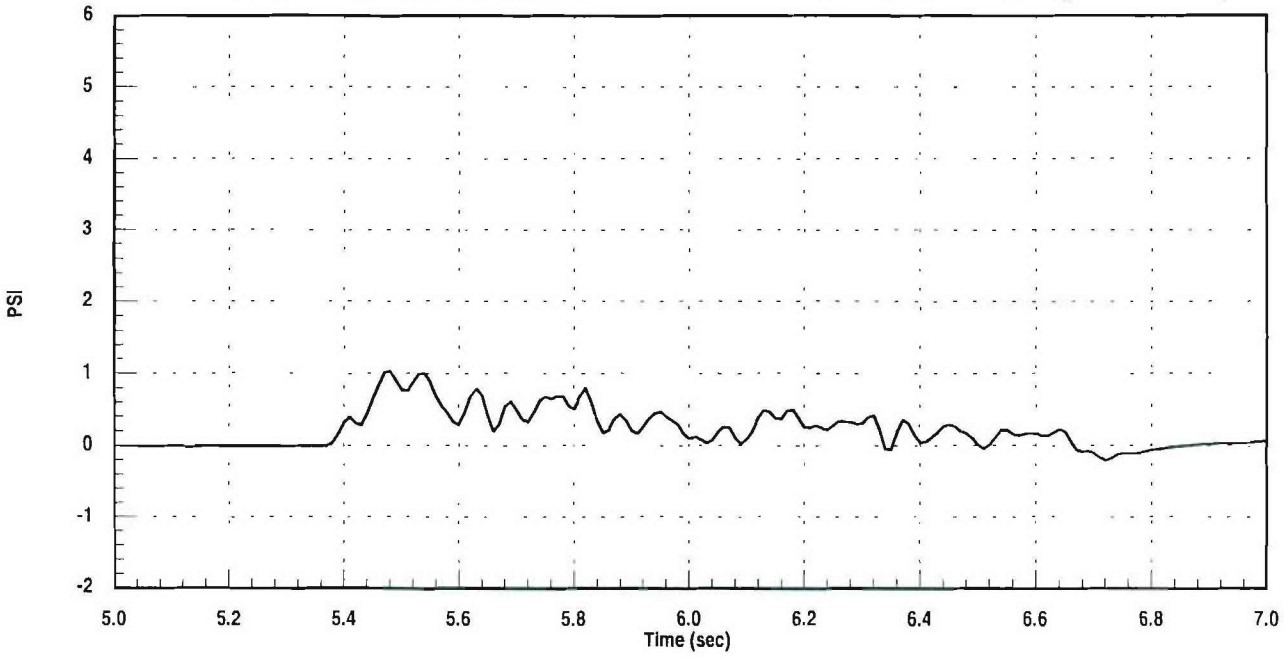
WD5, 375 KEAS

Post / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



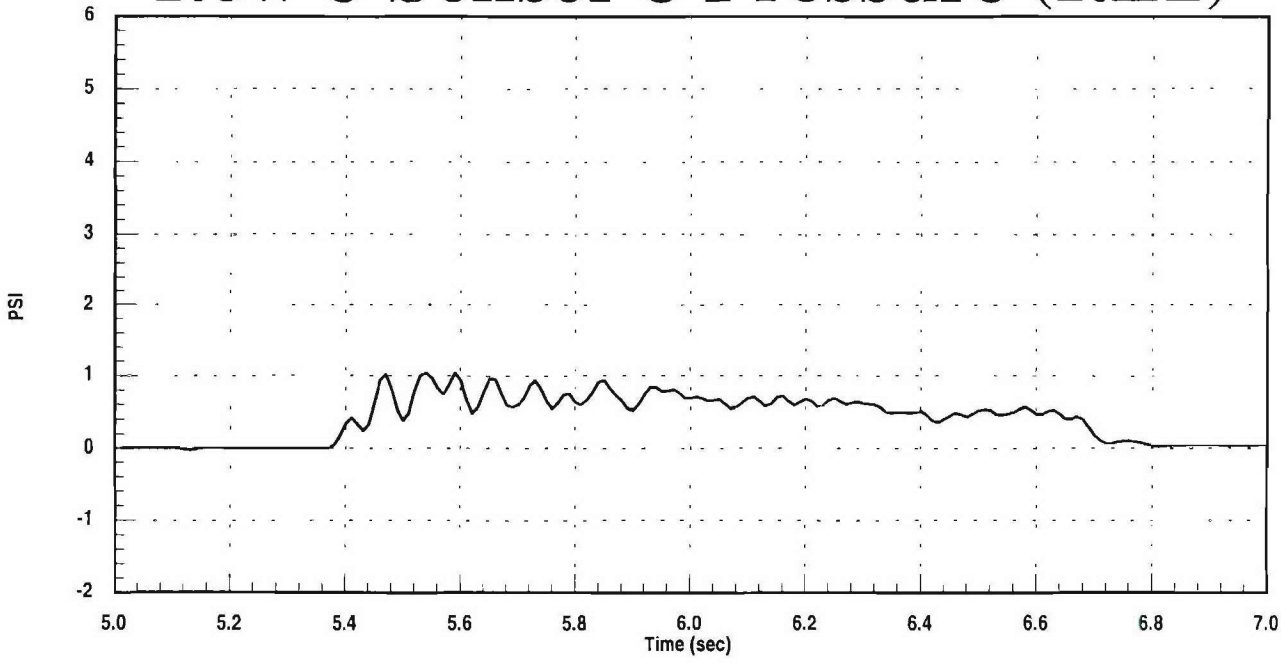
Row 5 Sensor 2 Pressure (LE2)



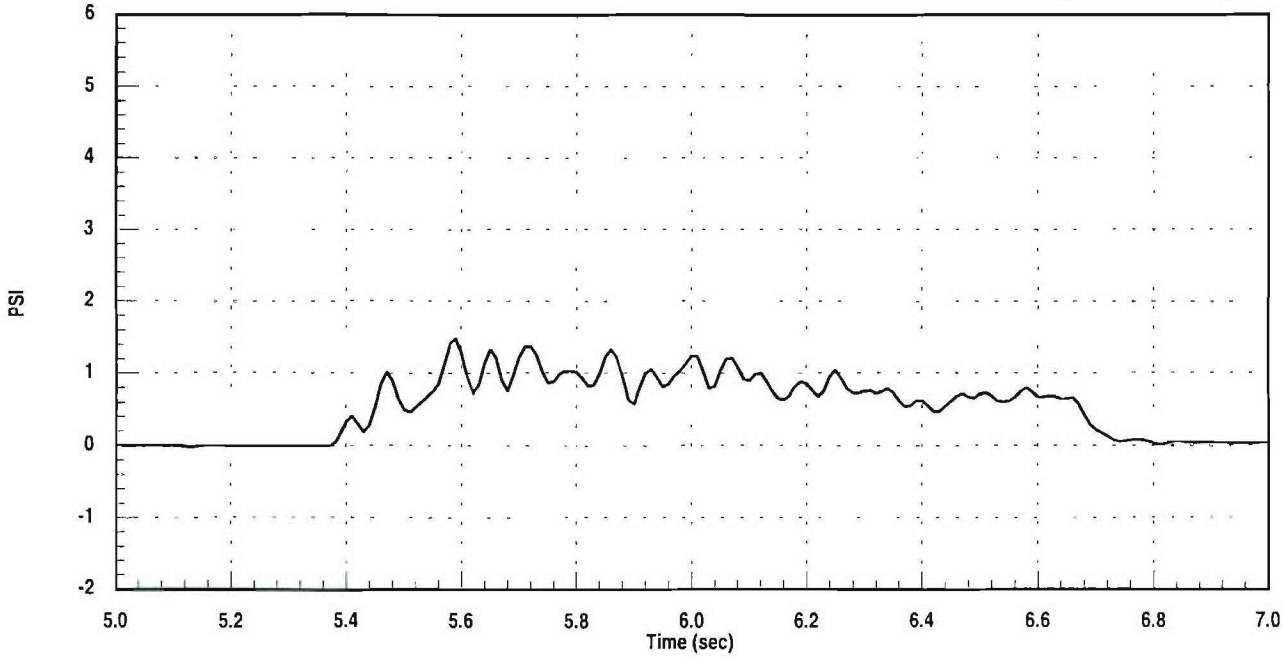
WD5, 375 KEAS

Post / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



WD6, 375 KEAS

T-38 Pillar / Torso Rake

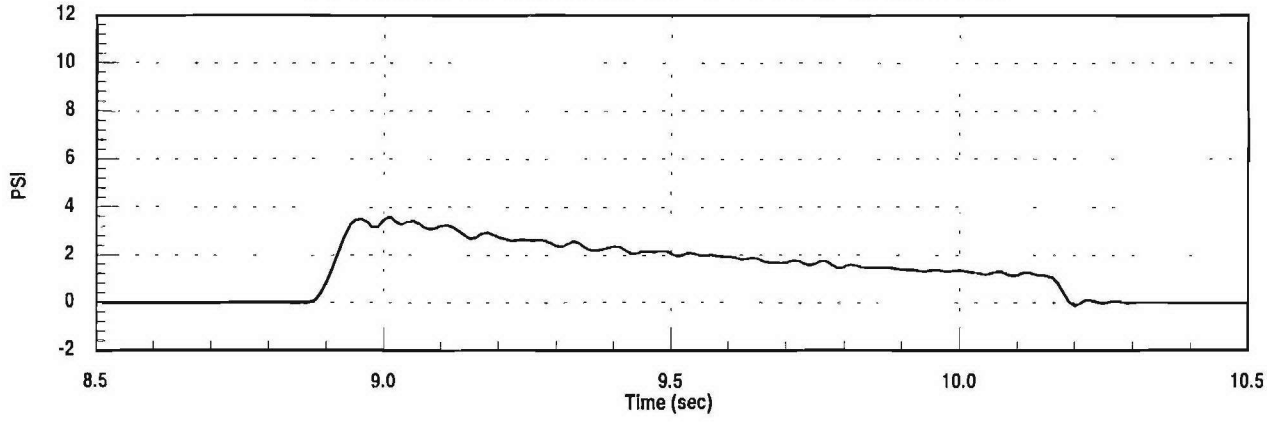
Processed Data

Main Rake and Inflatable Restraint Inner Pressure	E-58
Row 1 Sensor 1 & 2 Pressures	E-59
Row 1 Sensor 3 & 4 Pressures	E-60
Row 2 Sensor 1 & 2 Pressures	E-61
Row 2 Sensor 3 & 4 Pressures	E-62
Row 3 Sensor 1 & 2 Pressures	E-63
Row 3 Sensor 3 & 4 Pressures	E-64
Row 4 Sensor 1 & 2 Pressures	E-65
Row 4 Sensor 3 & 4 Pressures	E-66
Row 5 Sensor 1 & 2 Pressures	E-67
Row 5 Sensor 3 & 4 Pressures	E-68

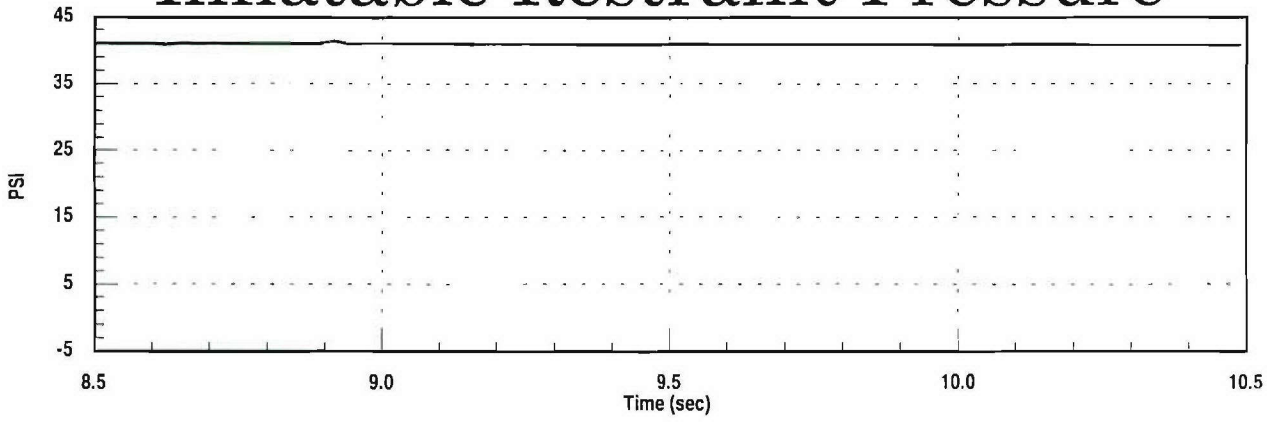
WD6, 375 KEAS

T-38 Pillar / Torso Rake

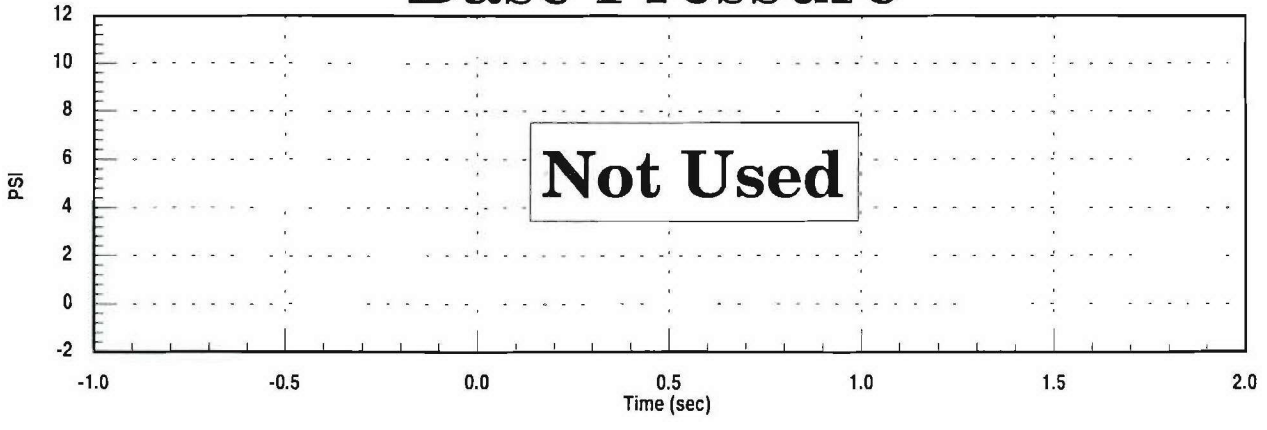
Main Rake Pressure



Inflatable Restraint Pressure



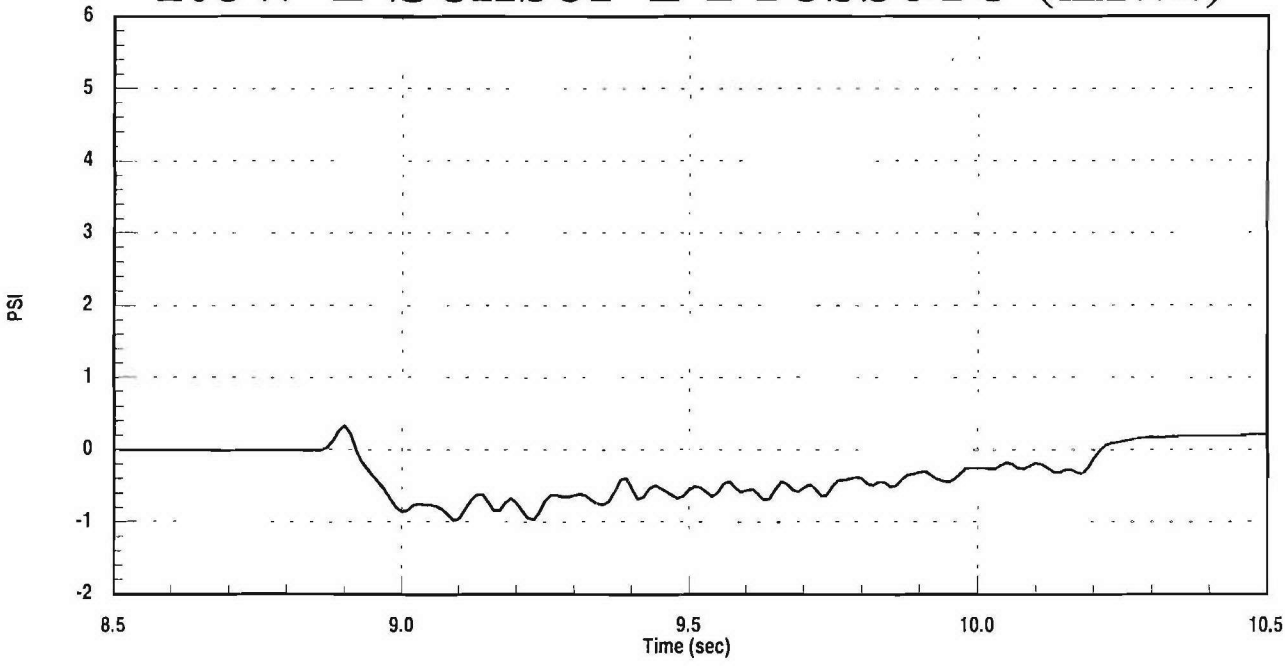
Base Pressure



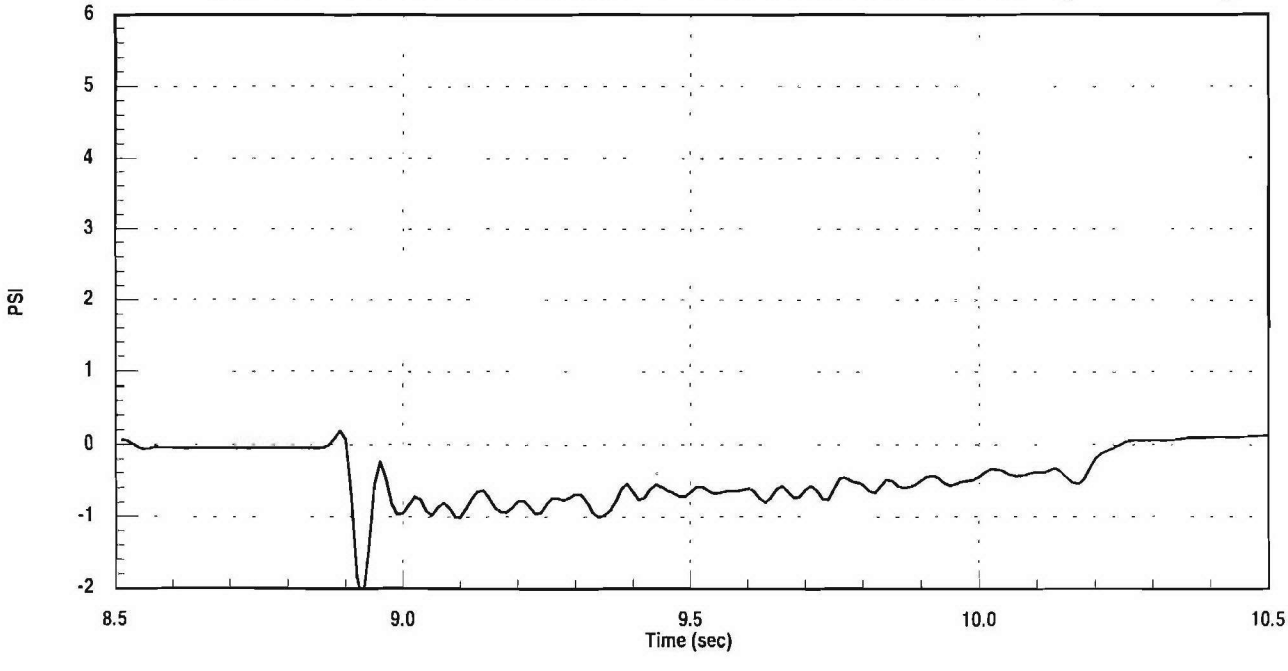
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



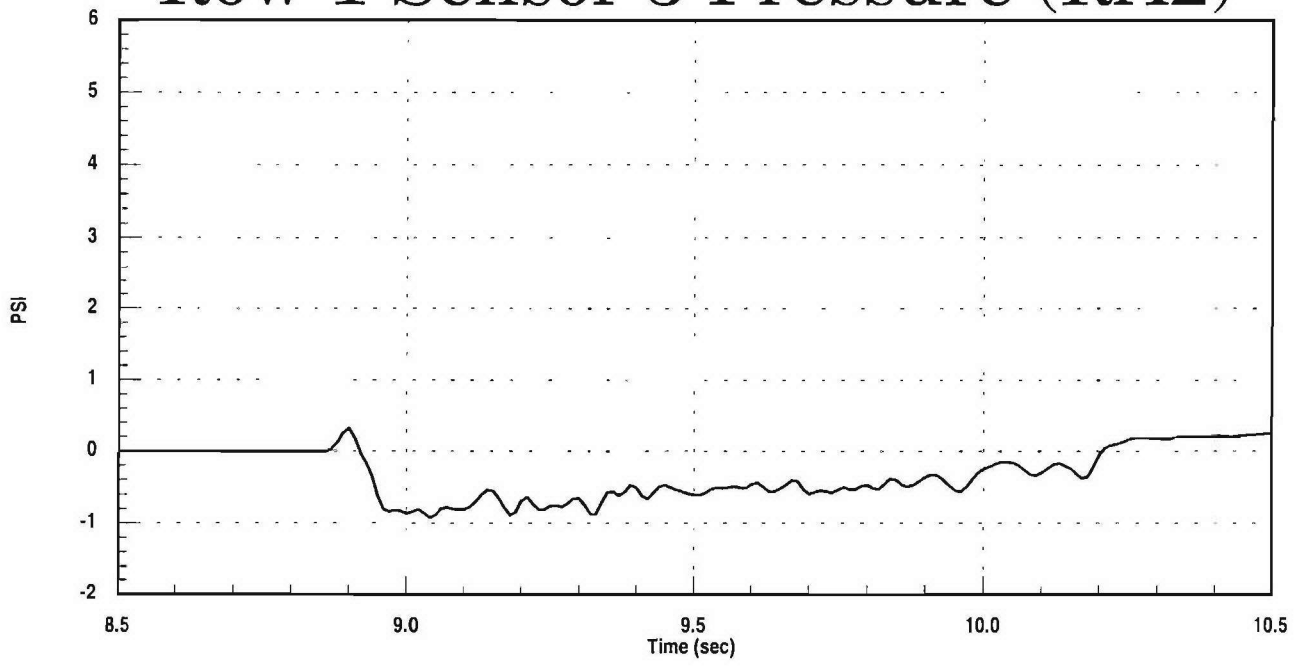
Row 1 Sensor 2 Pressure (LA2)



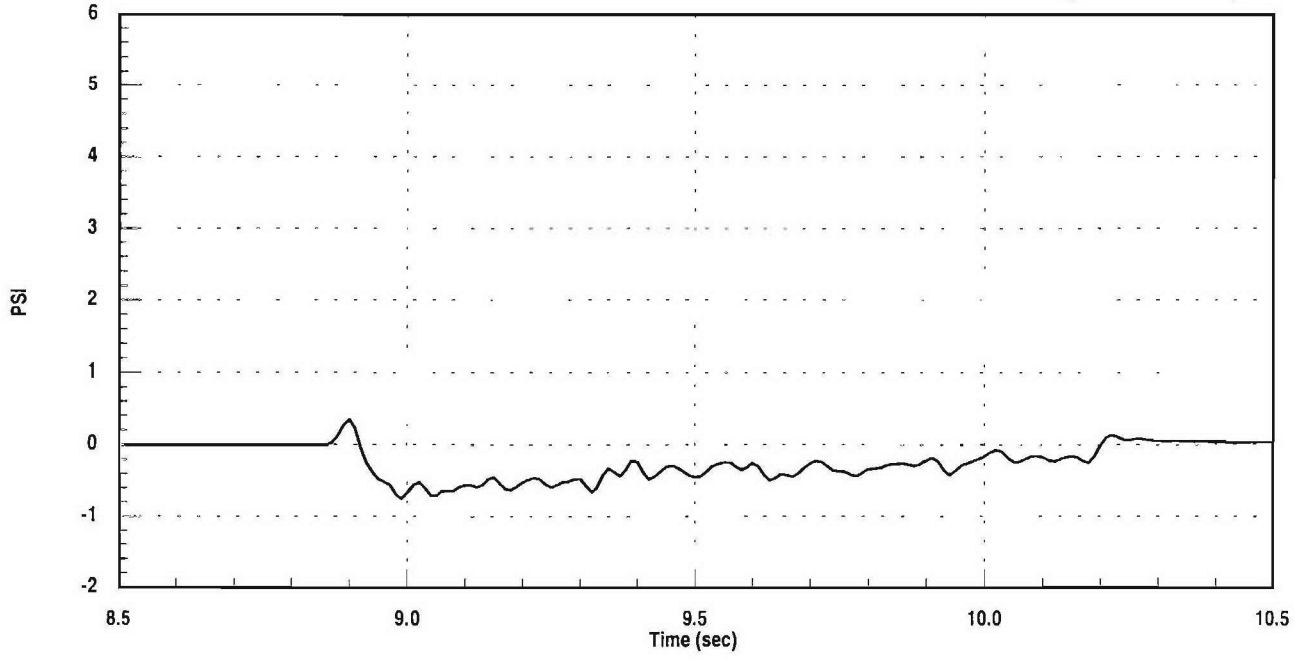
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



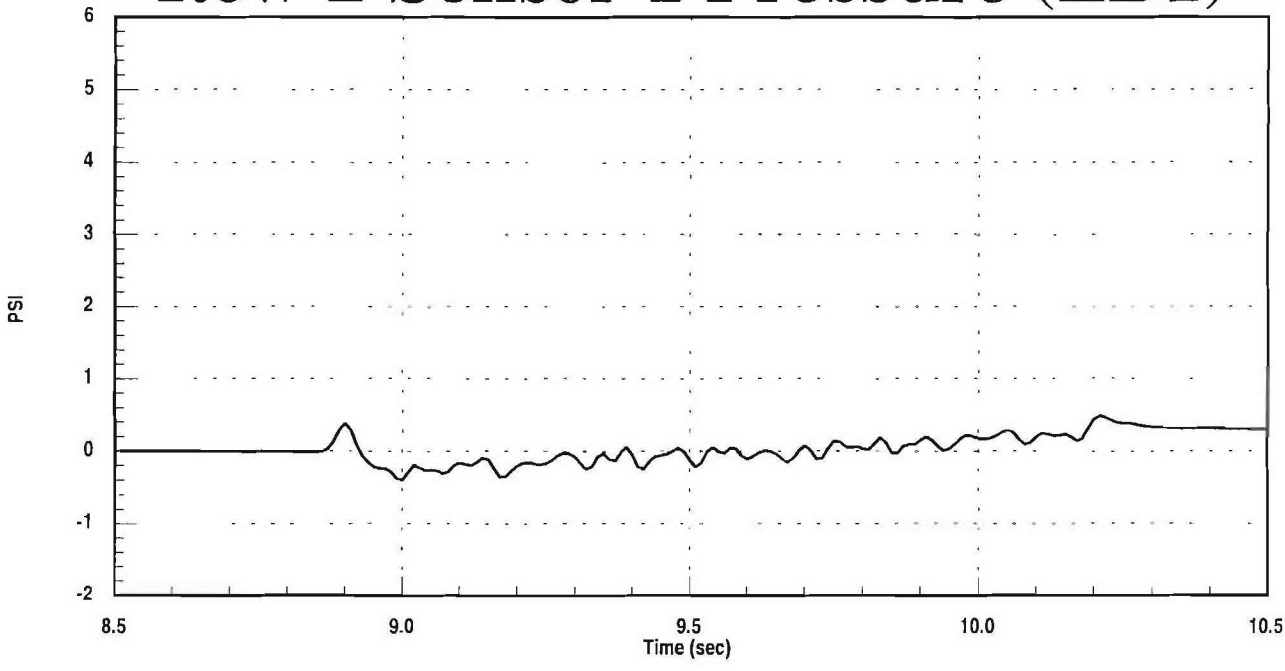
Row 1 Sensor 4 Pressure (RA1)



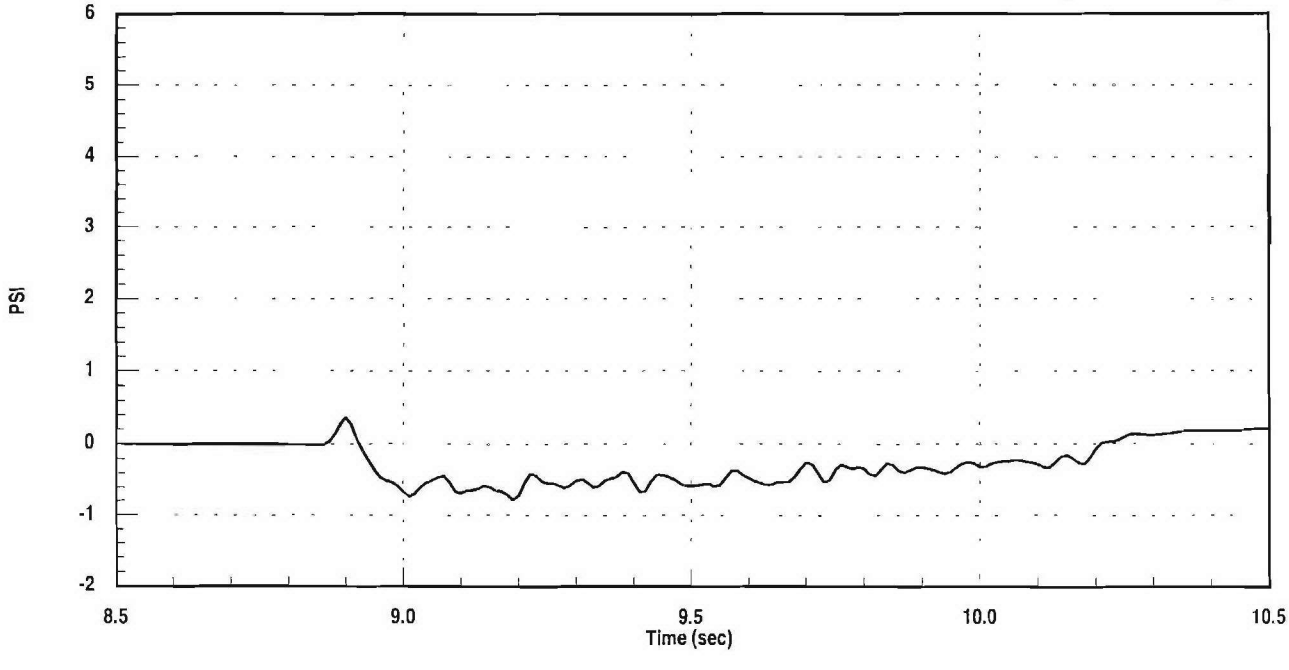
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



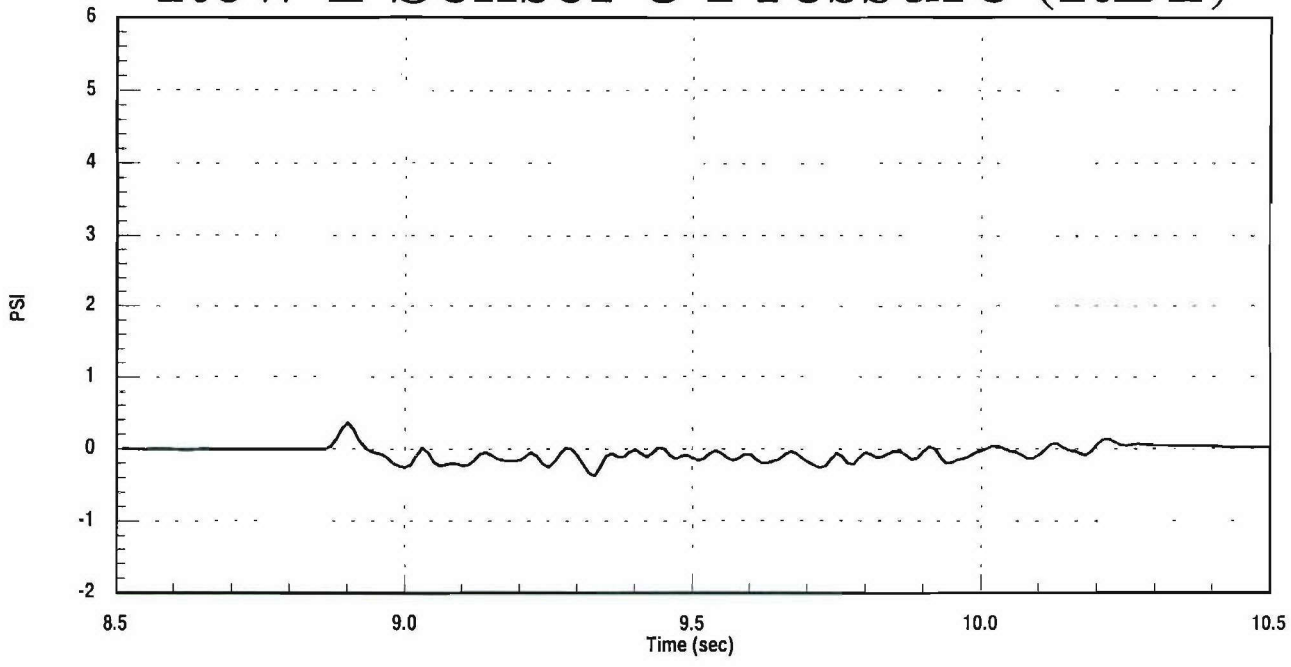
Row 2 Sensor 2 Pressure (LB2)



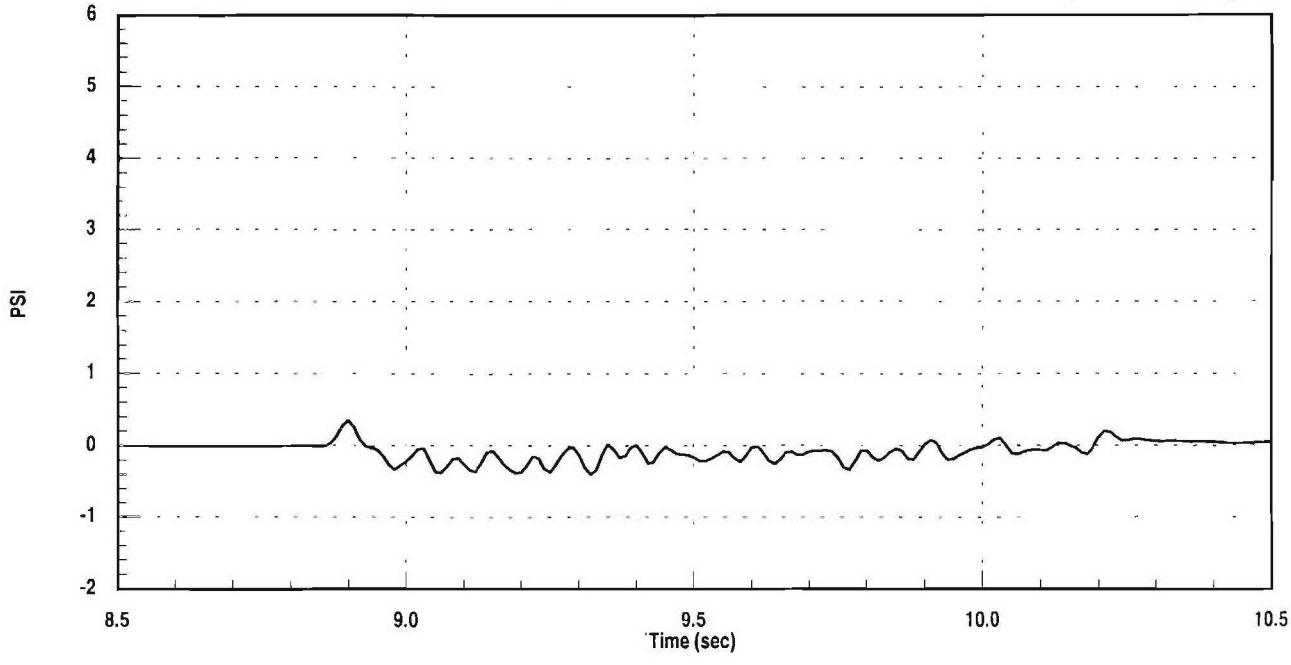
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



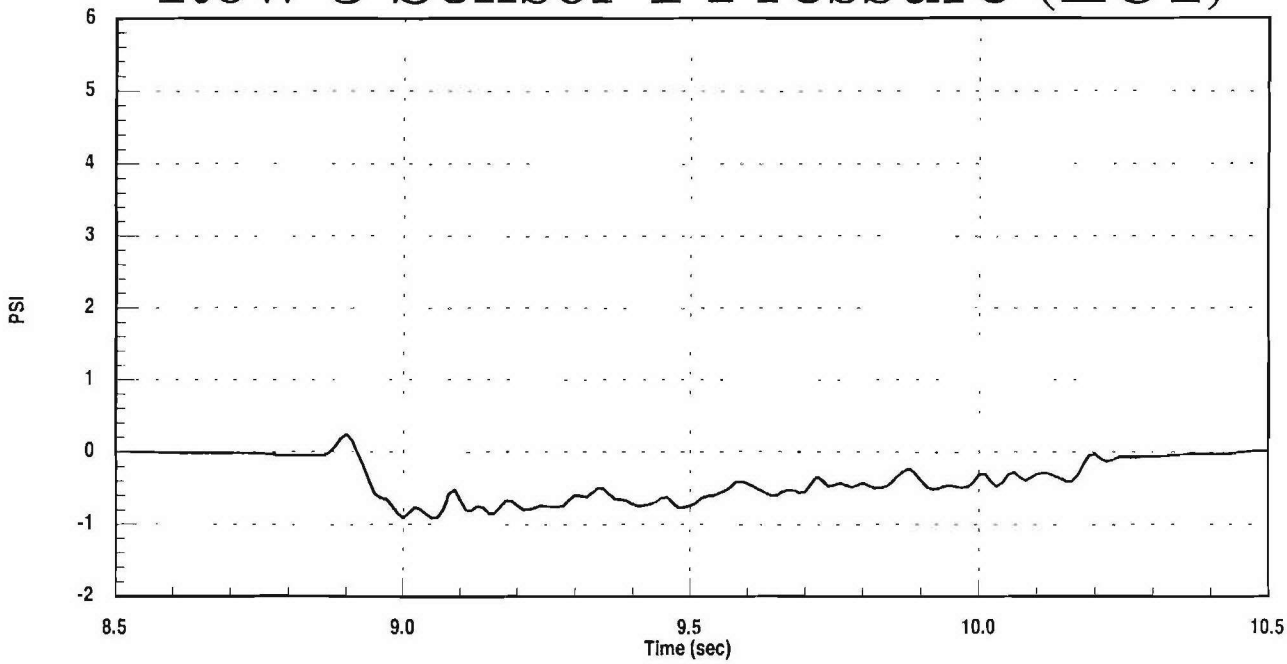
Row 2 Sensor 4 Pressure (RB1)



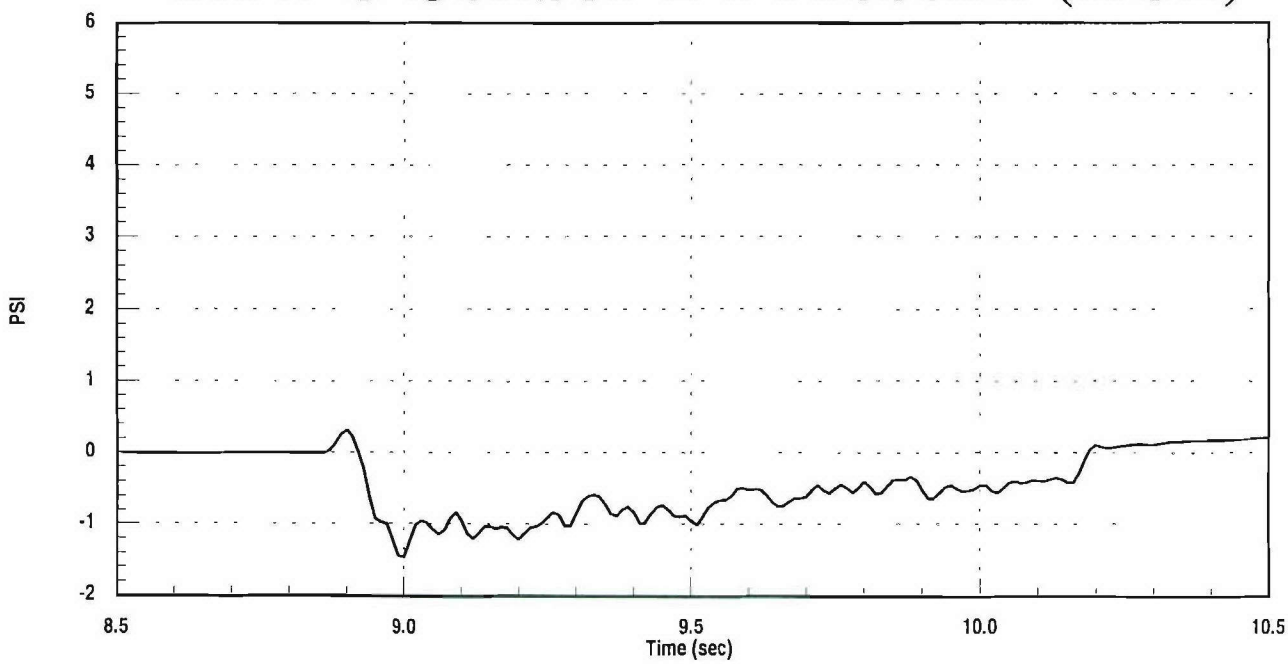
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



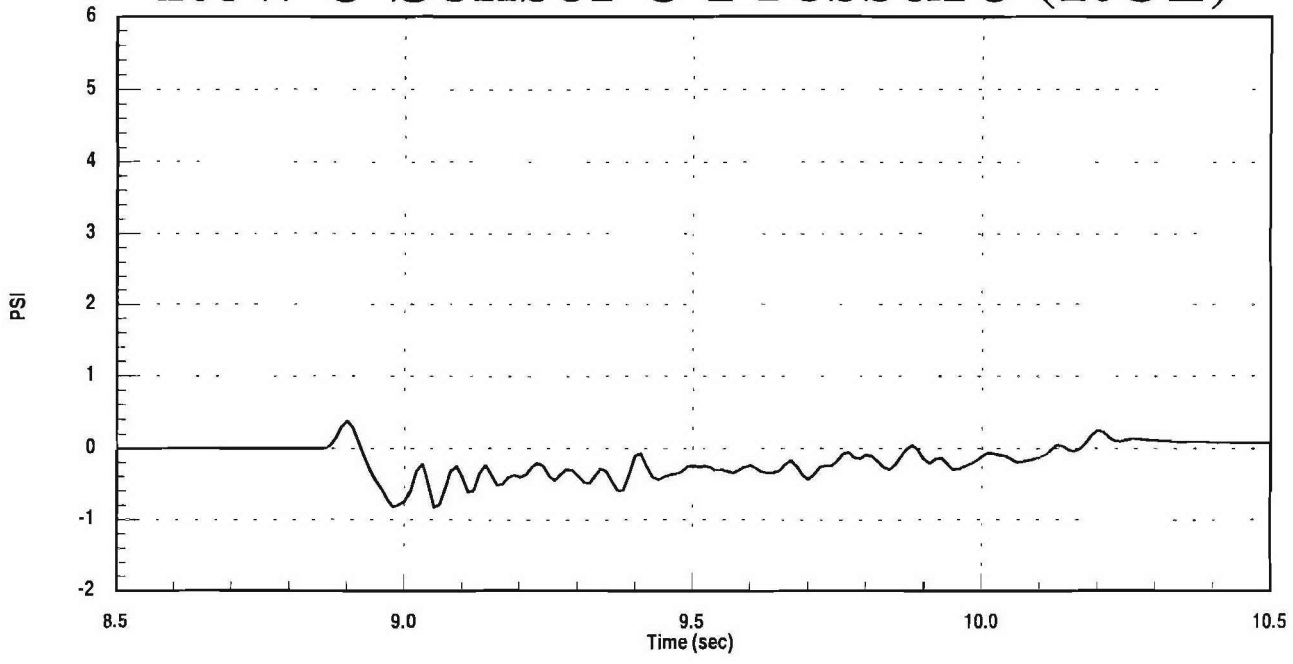
Row 3 Sensor 2 Pressure (LC2)



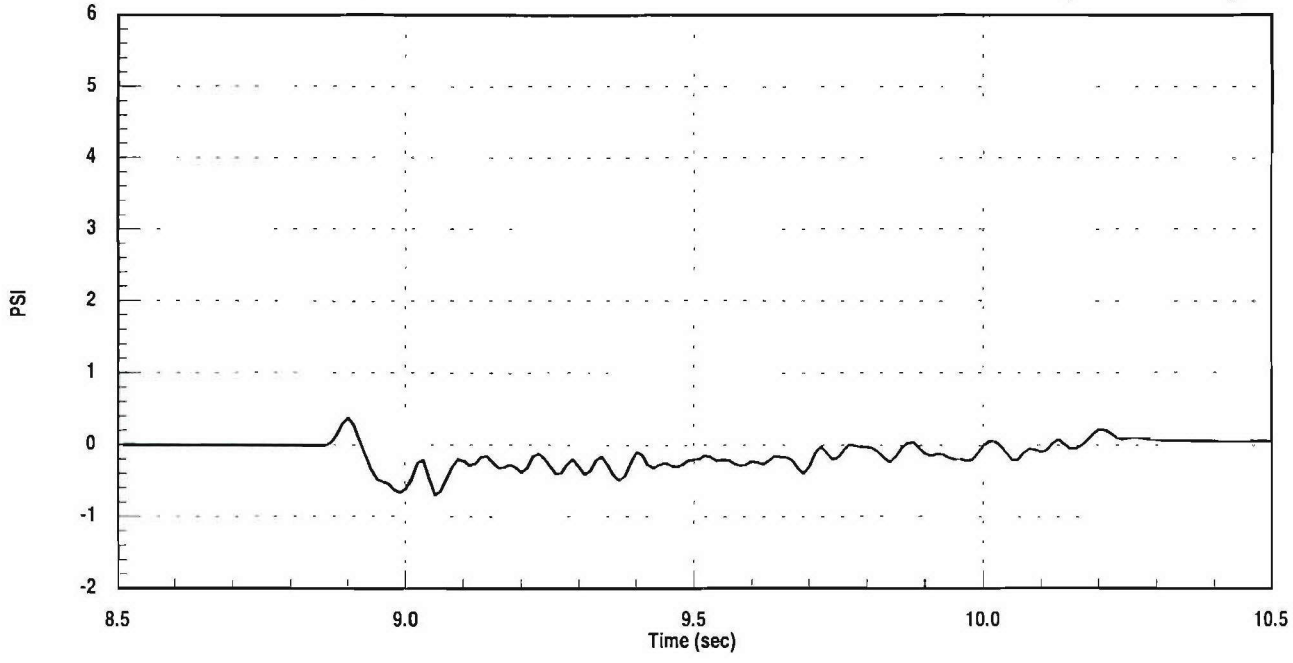
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



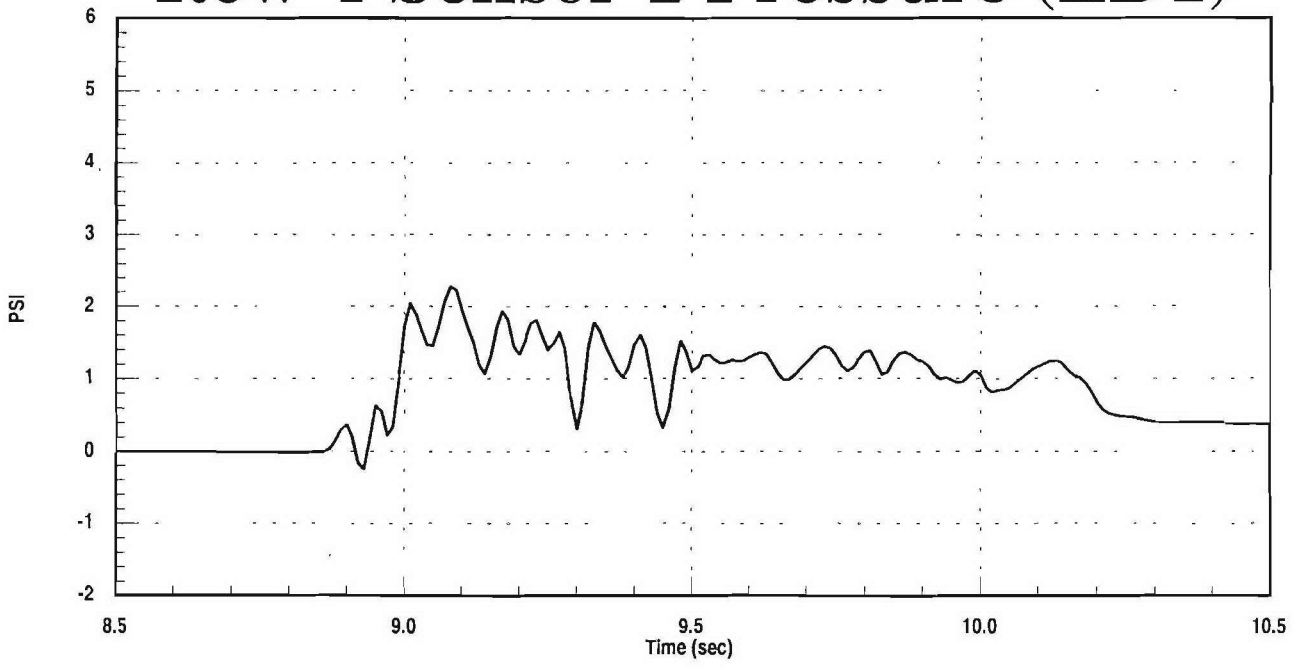
Row 3 Sensor 4 Pressure (RC1)



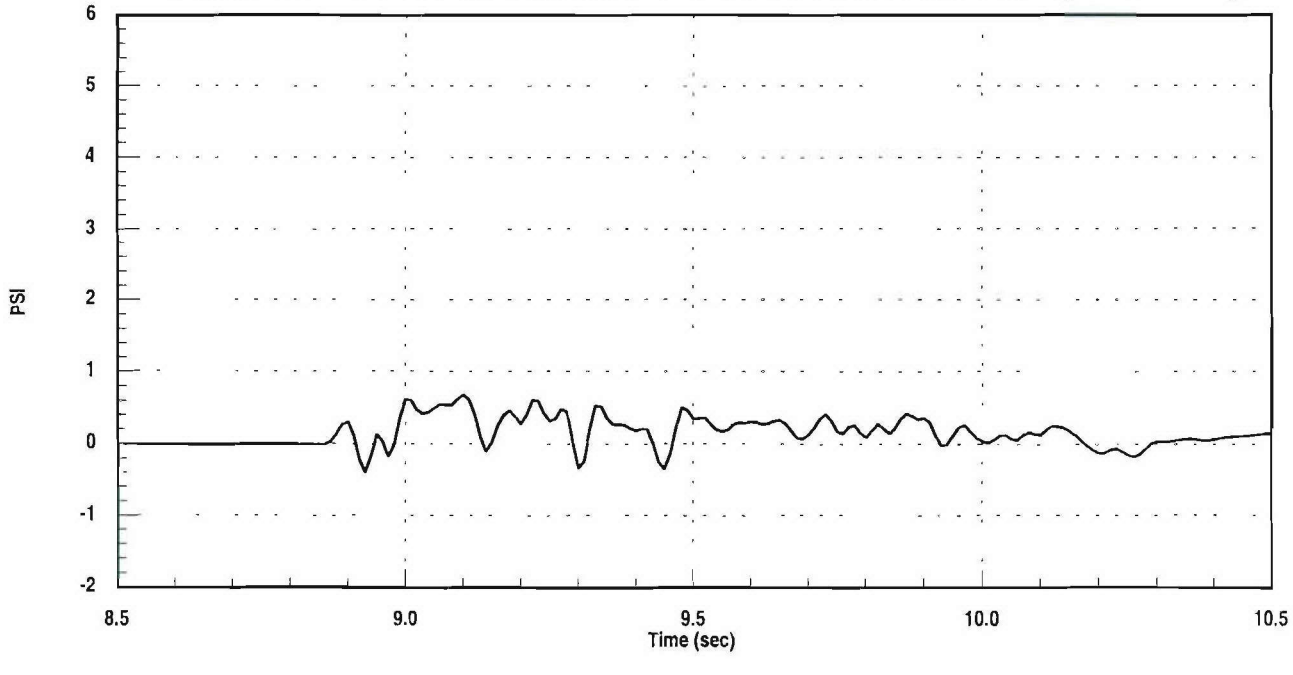
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



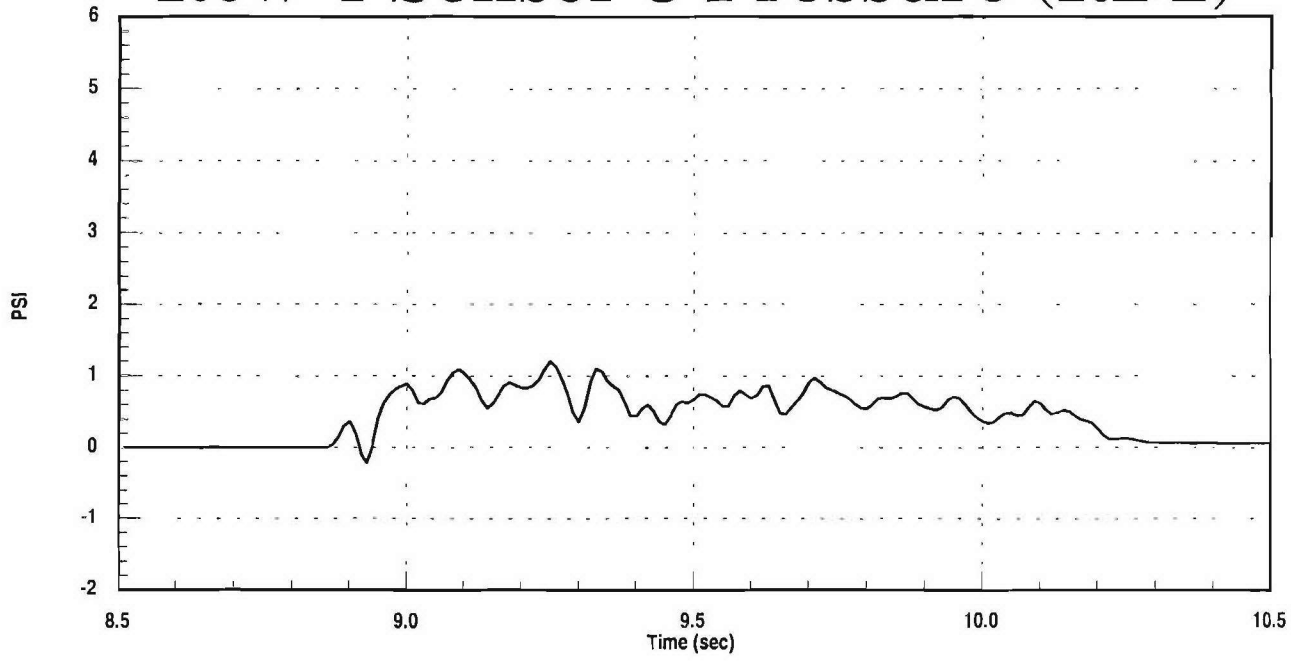
Row 4 Sensor 2 Pressure (LD2)



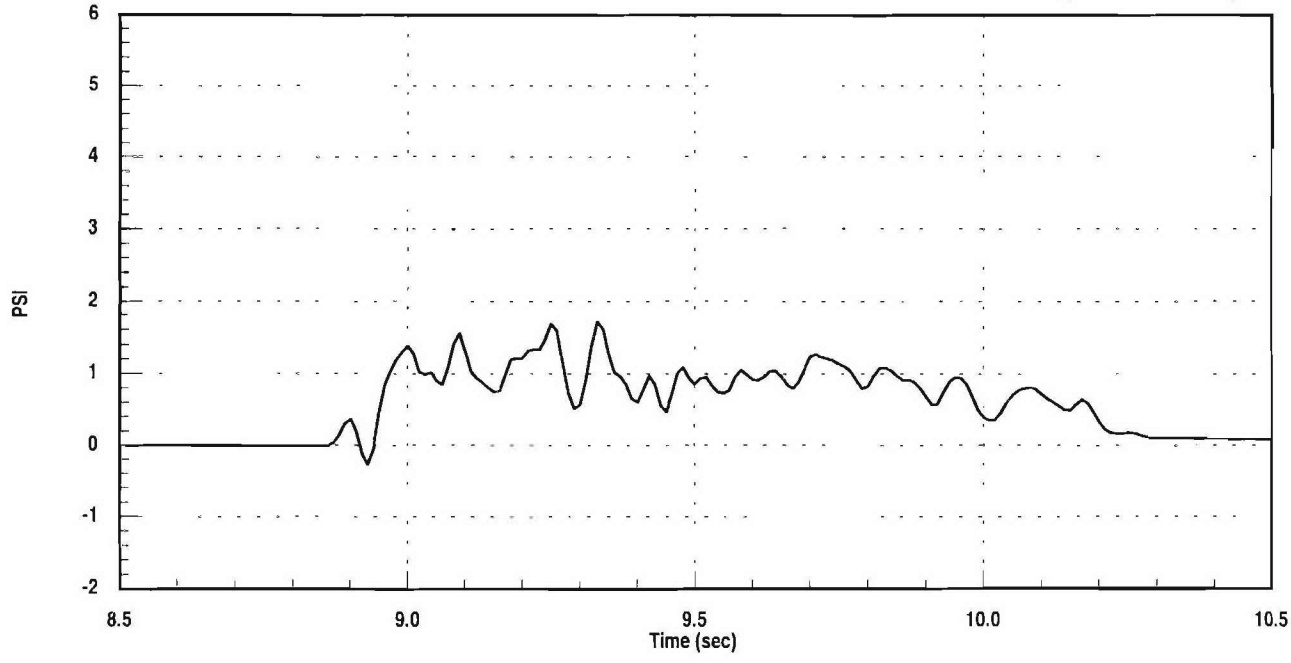
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



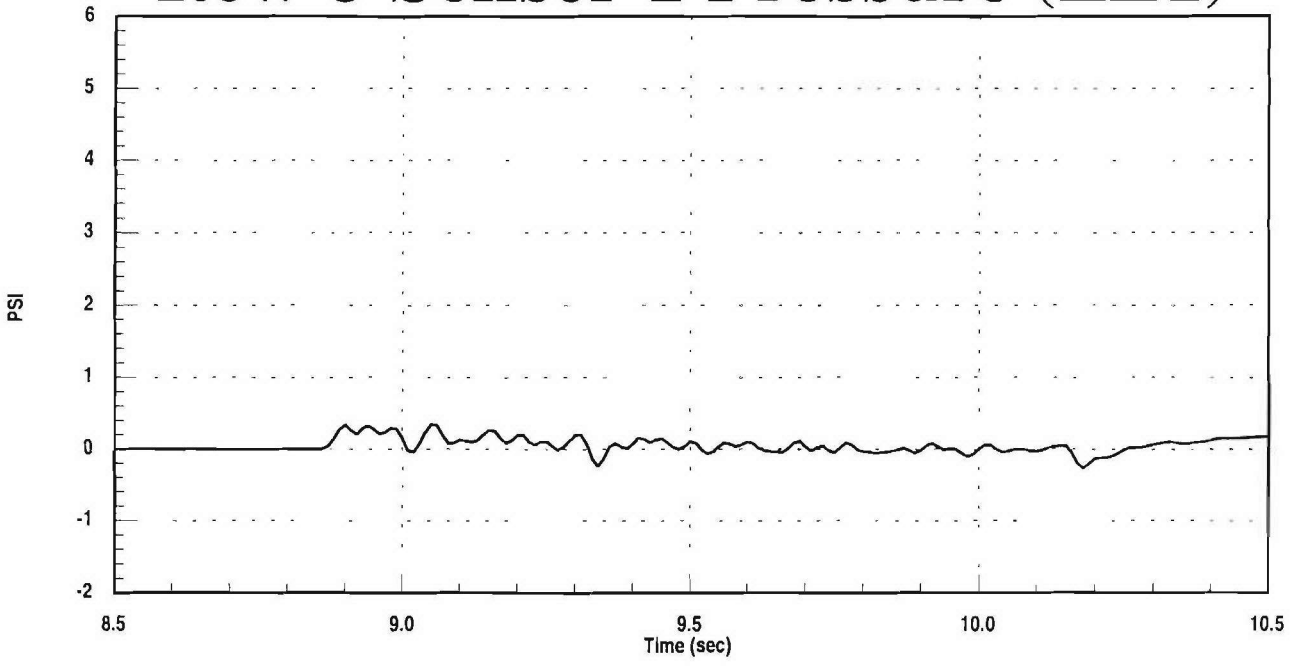
Row 4 Sensor 4 Pressure (RD1)



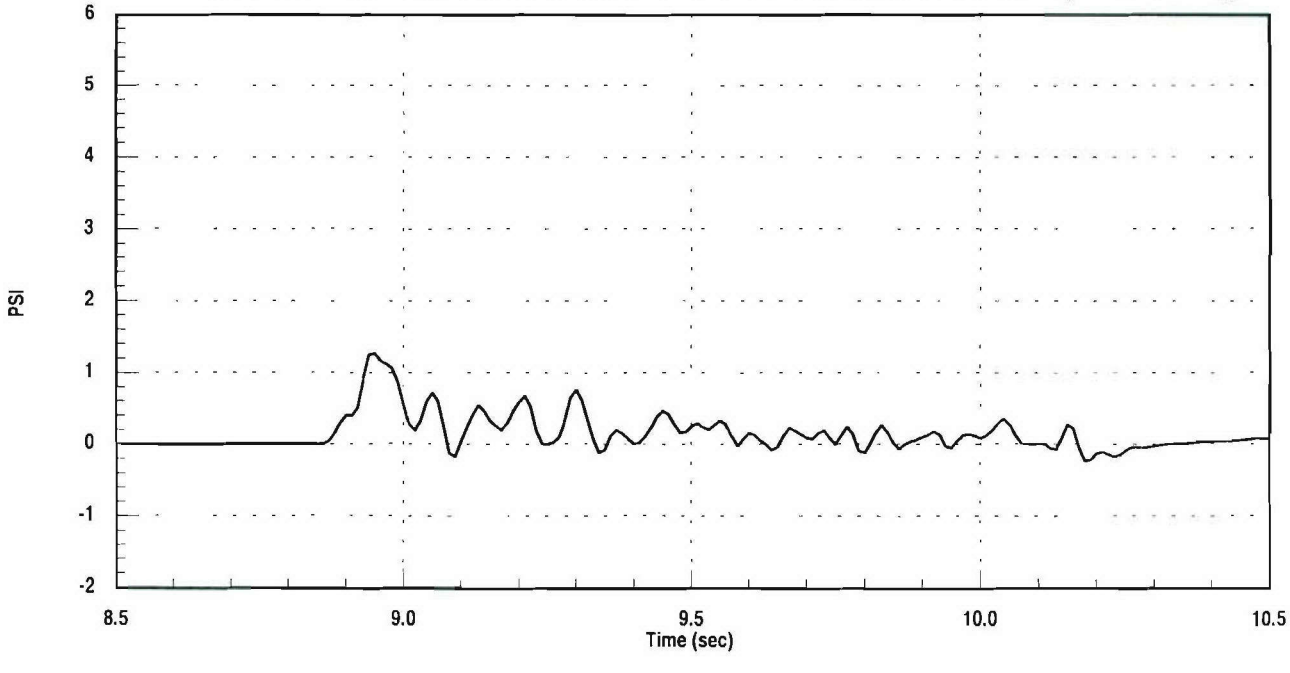
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



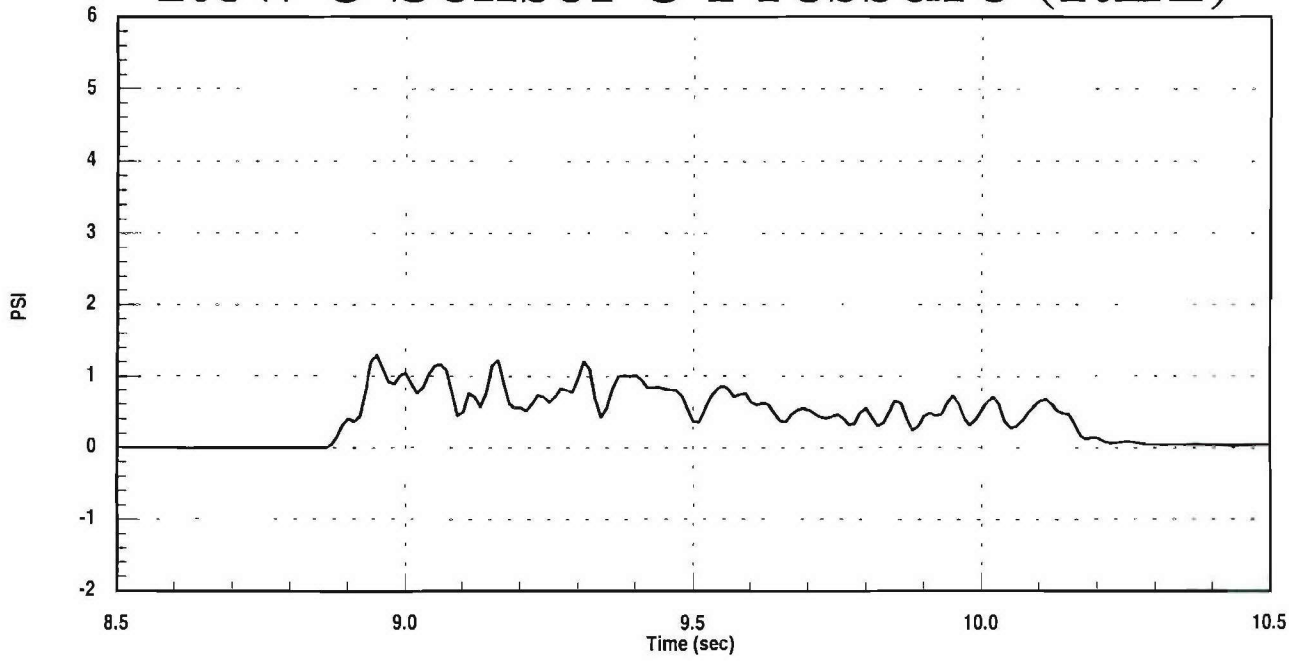
Row 5 Sensor 2 Pressure (LE2)



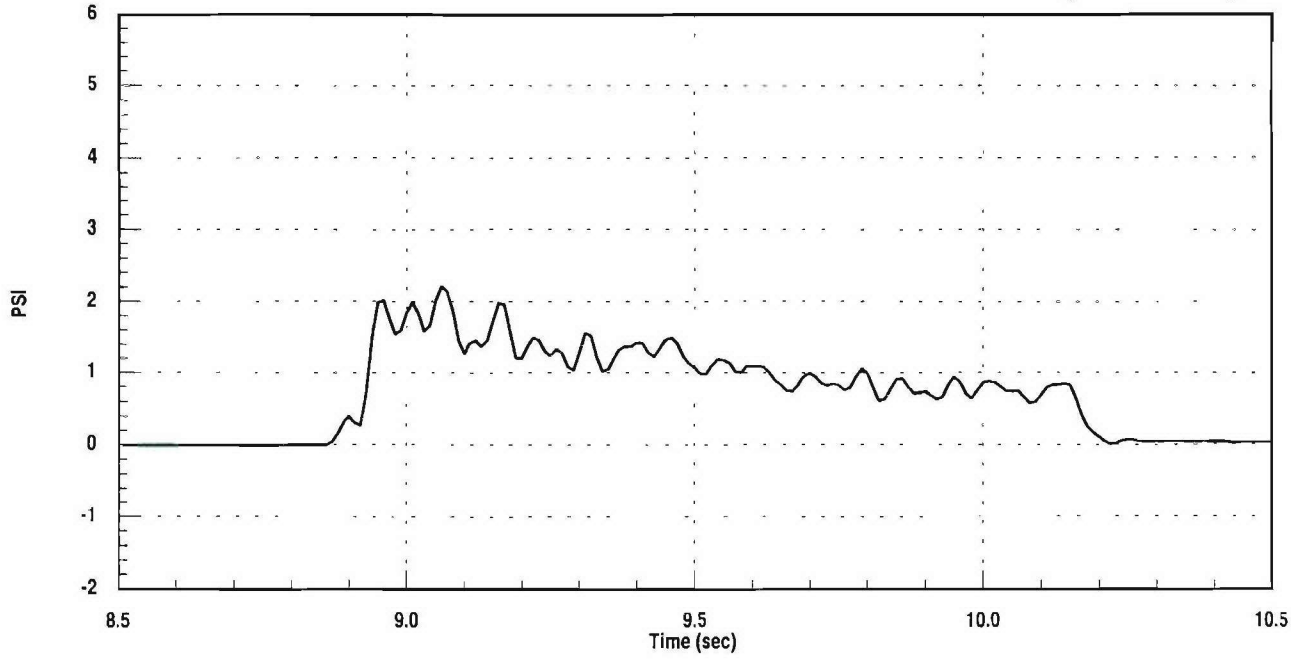
WD6, 375 KEAS

T-38 Pillar / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



WD7, 450 KEAS

T-38 Pillar / Torso Rake

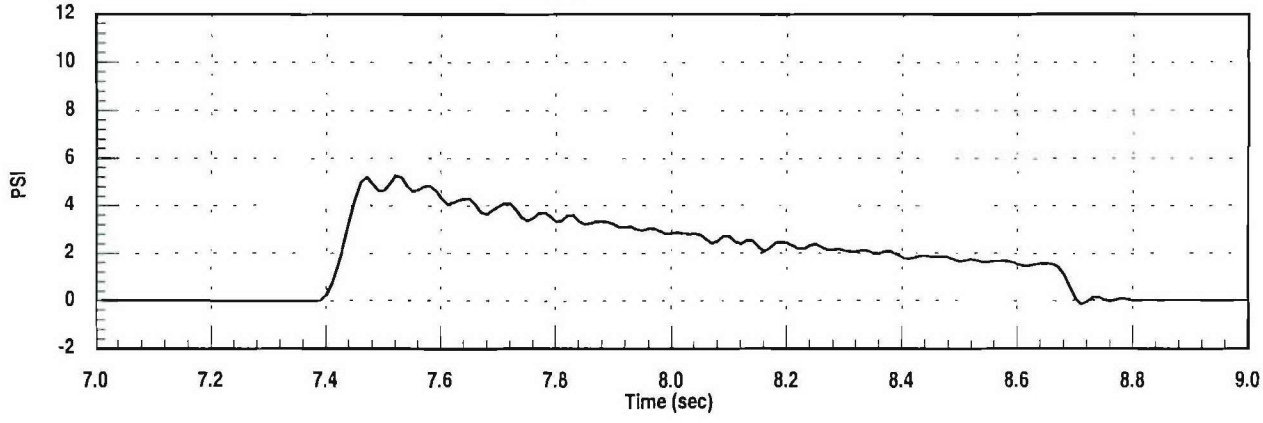
Processed Data

Main Rake and Inflatable Restraint Inner Pressure	E-69
Row 1 Sensor 1 & 2 Pressures	E-70
Row 1 Sensor 3 & 4 Pressures	E-71
Row 2 Sensor 1 & 2 Pressures	E-72
Row 2 Sensor 3 & 4 Pressures	E-73
Row 3 Sensor 1 & 2 Pressures	E-74
Row 3 Sensor 3 & 4 Pressures	E-75
Row 4 Sensor 1 & 2 Pressures	E-76
Row 4 Sensor 3 & 4 Pressures	E-77
Row 5 Sensor 1 & 2 Pressures	E-78
Row 5 Sensor 3 & 4 Pressures	E-79

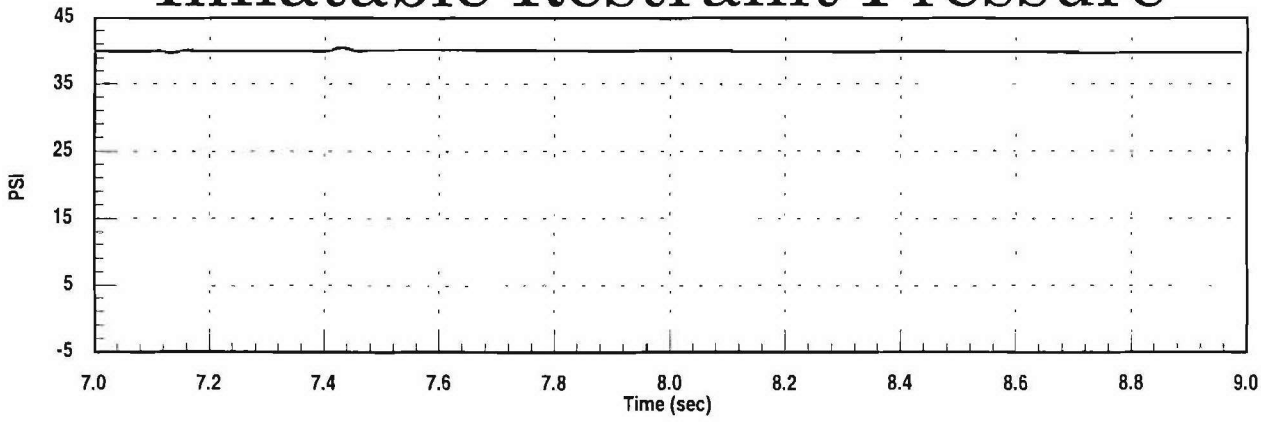
WD7, 450 KEAS

T-38 Pillar / Torso Rake

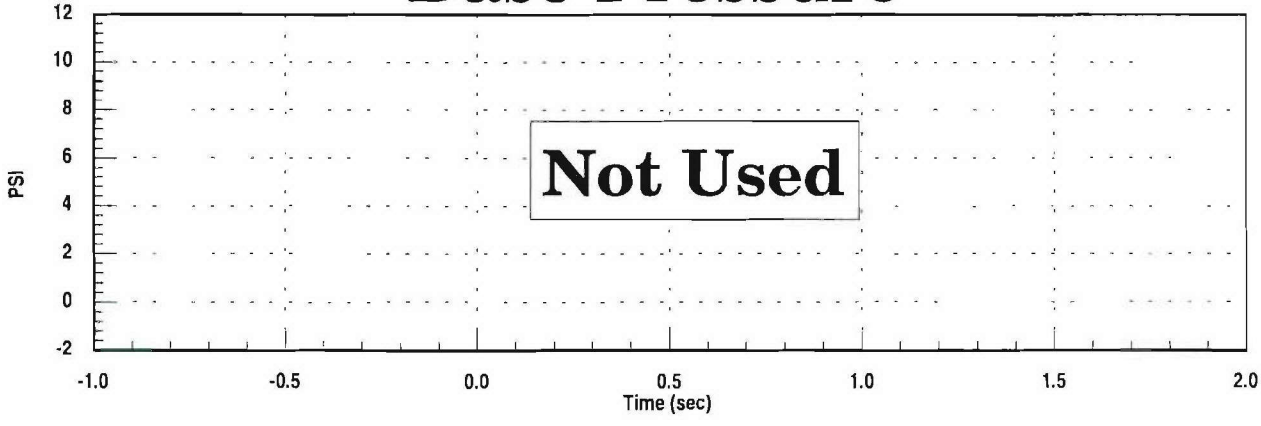
Main Rake Pressure



Inflatable Restraint Pressure



Base Pressure

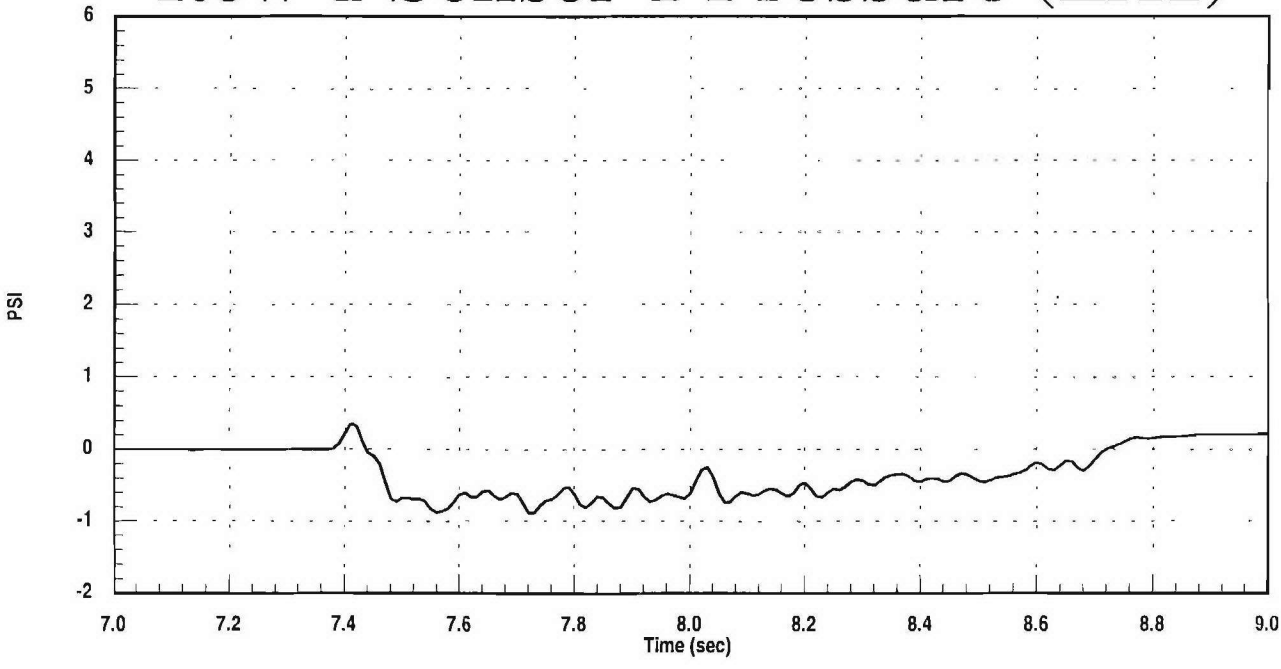


E-70

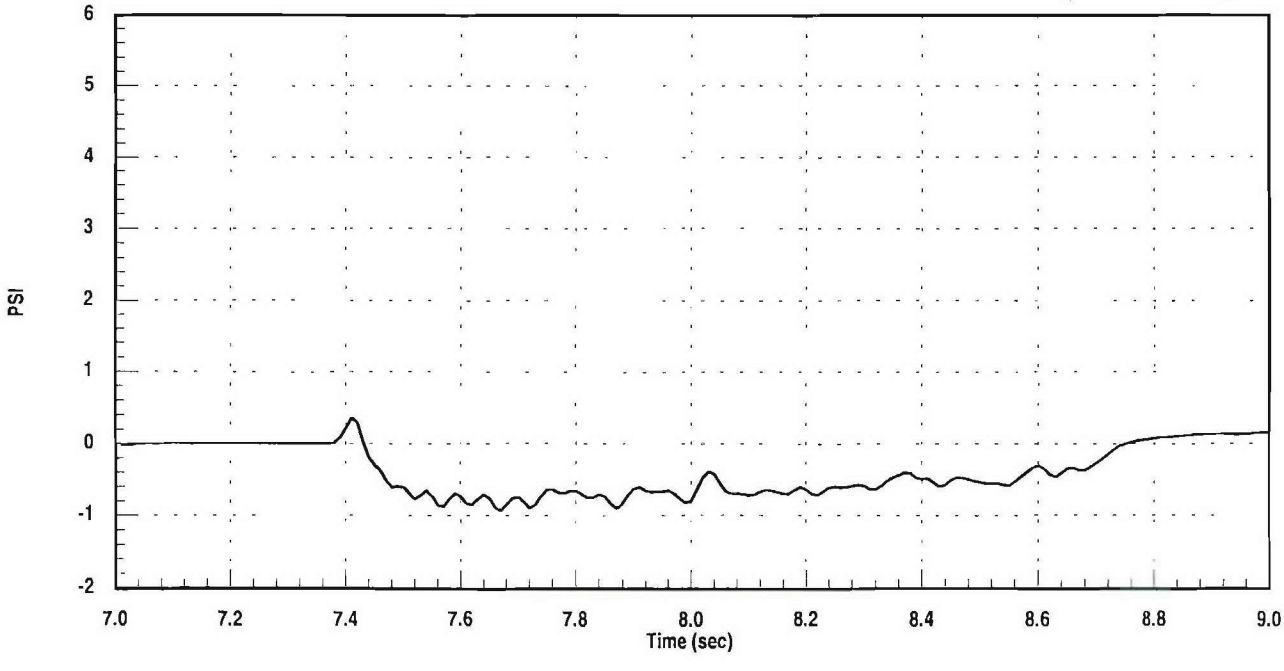
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



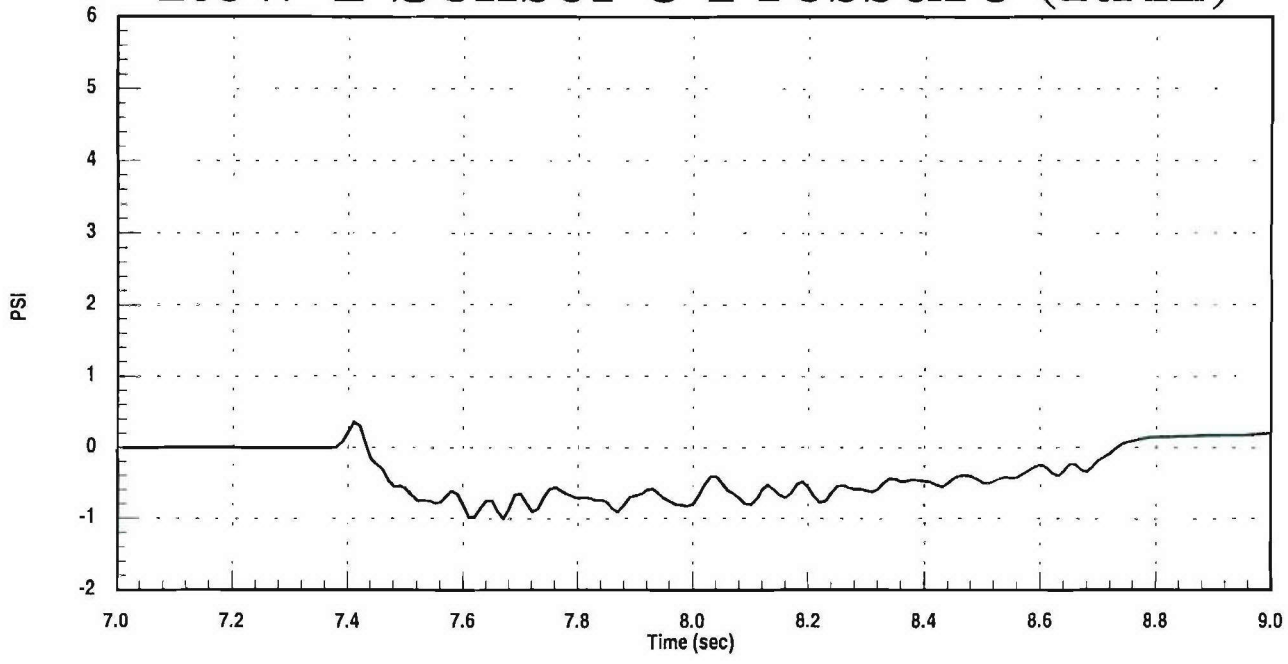
Row 1 Sensor 2 Pressure (LA2)



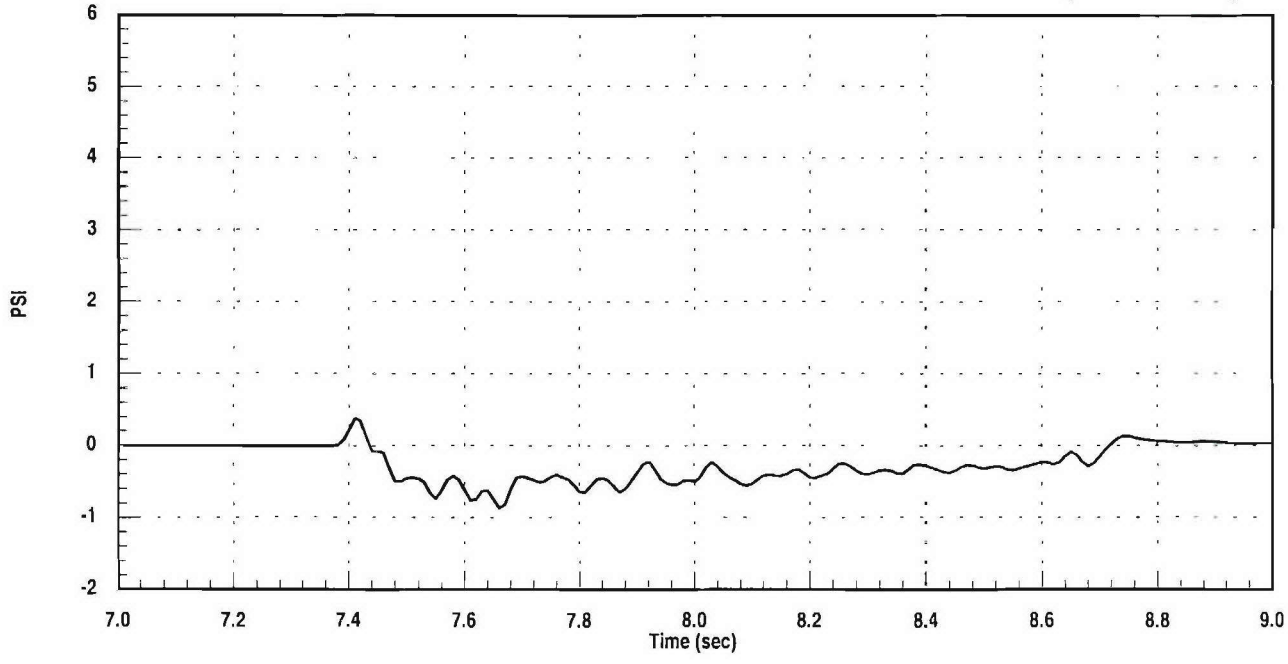
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



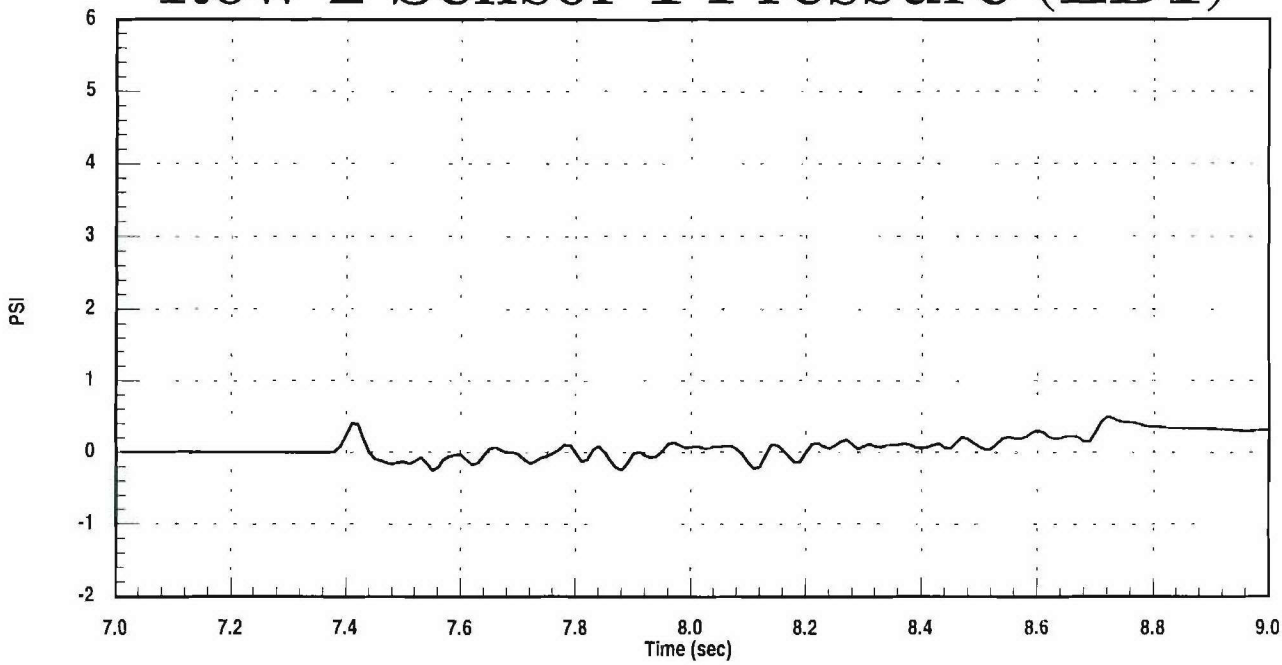
Row 1 Sensor 4 Pressure (RA1)



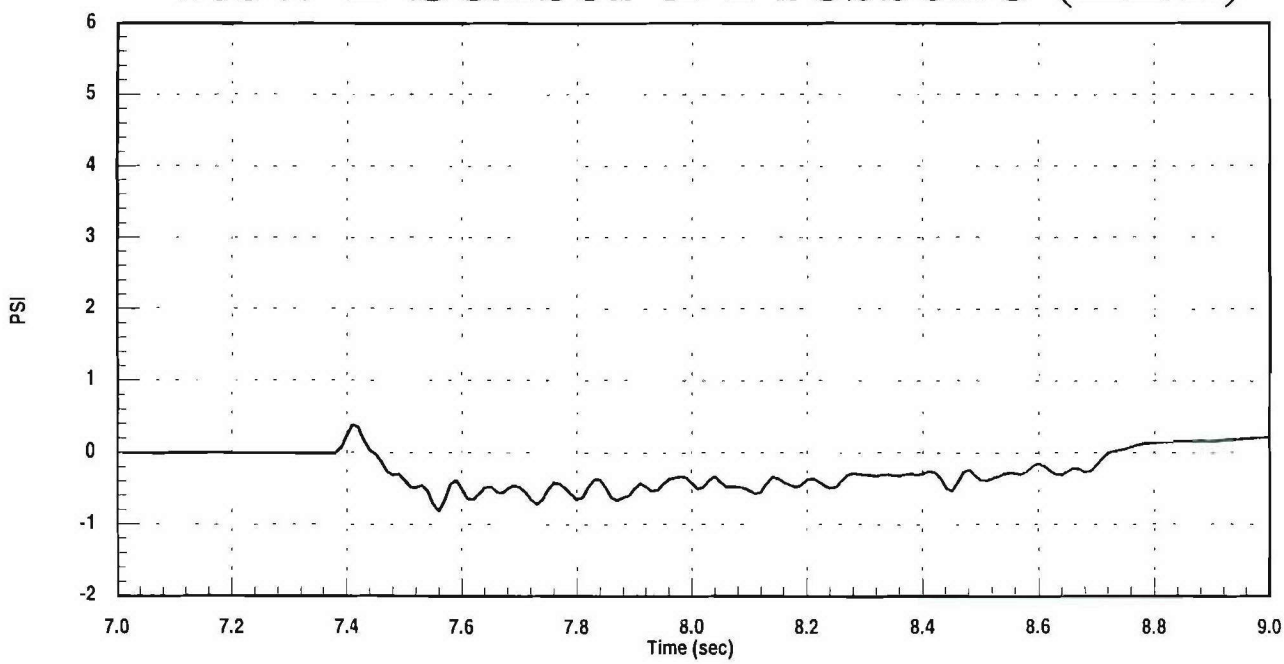
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



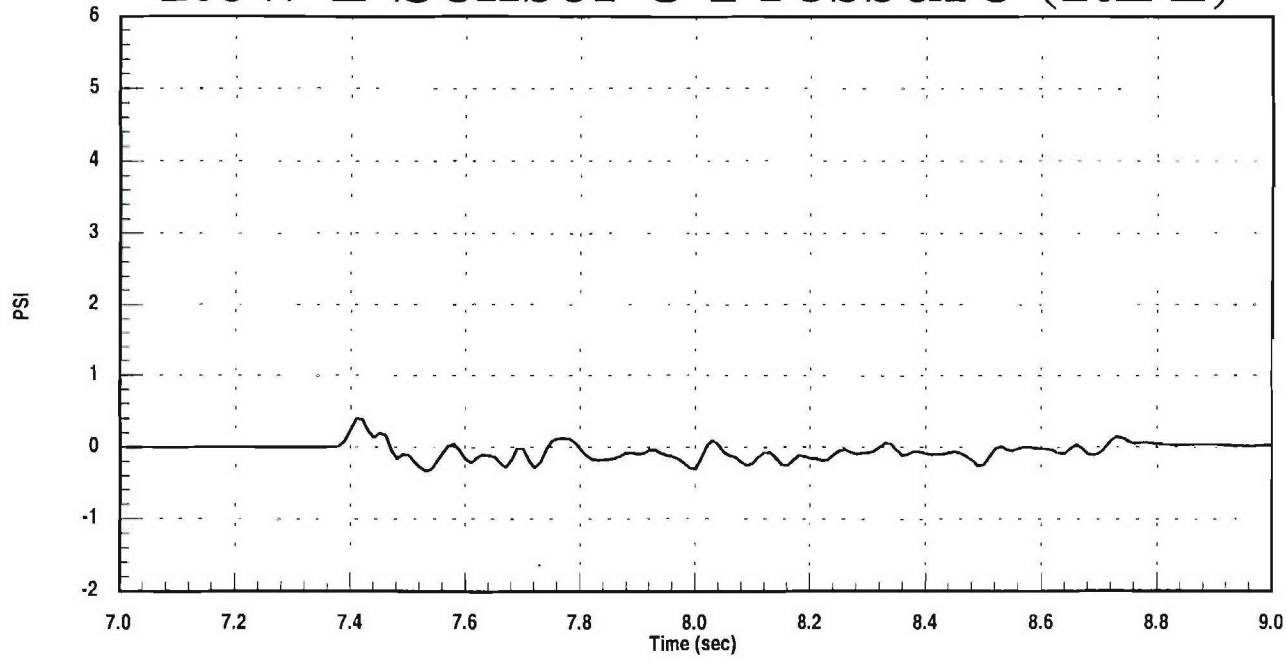
Row 2 Sensor 2 Pressure (LB2)



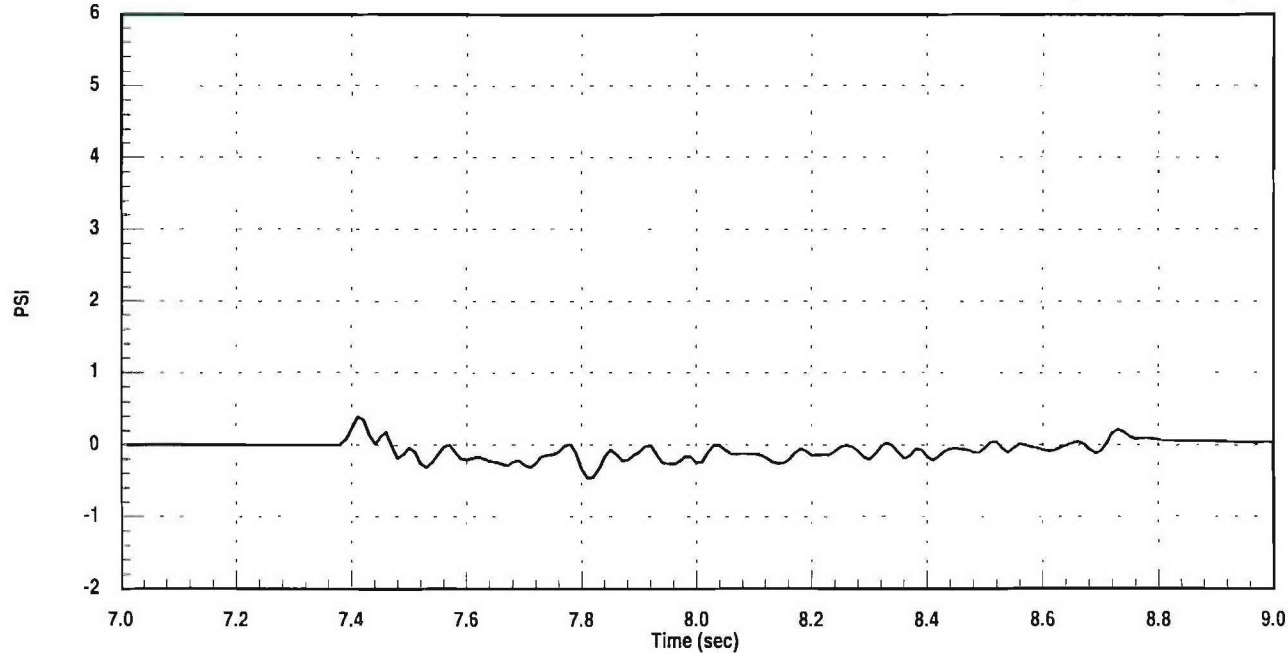
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



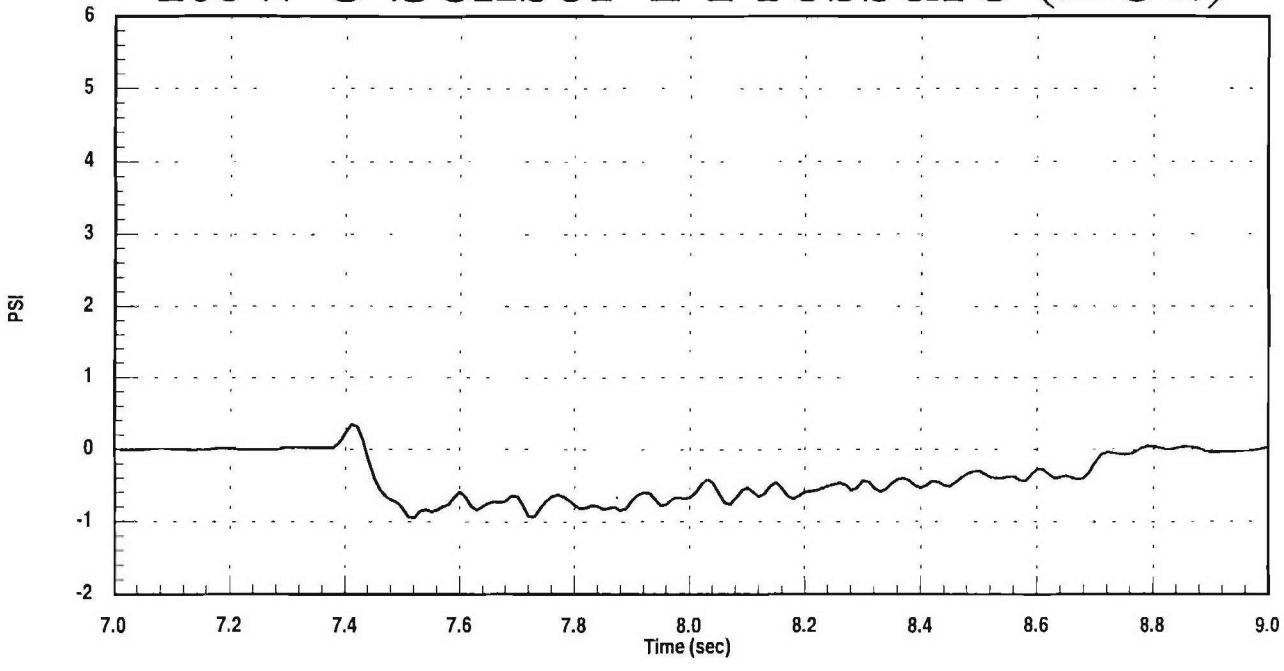
Row 2 Sensor 4 Pressure (RB1)



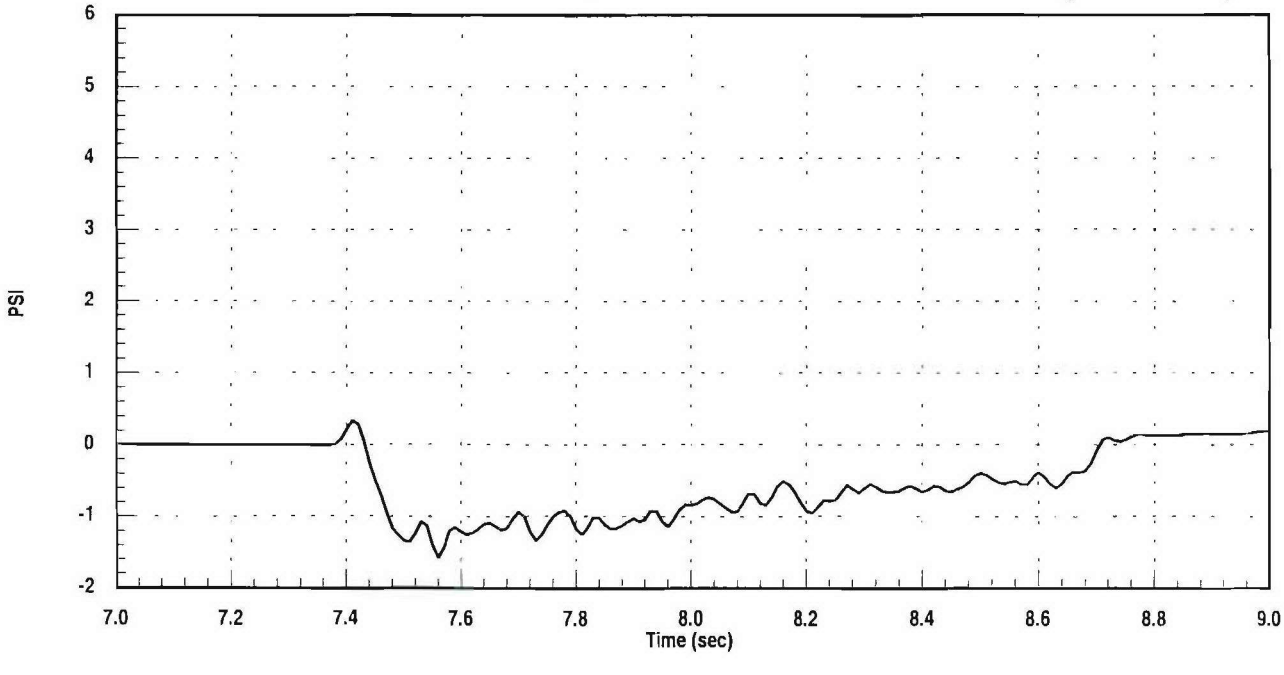
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



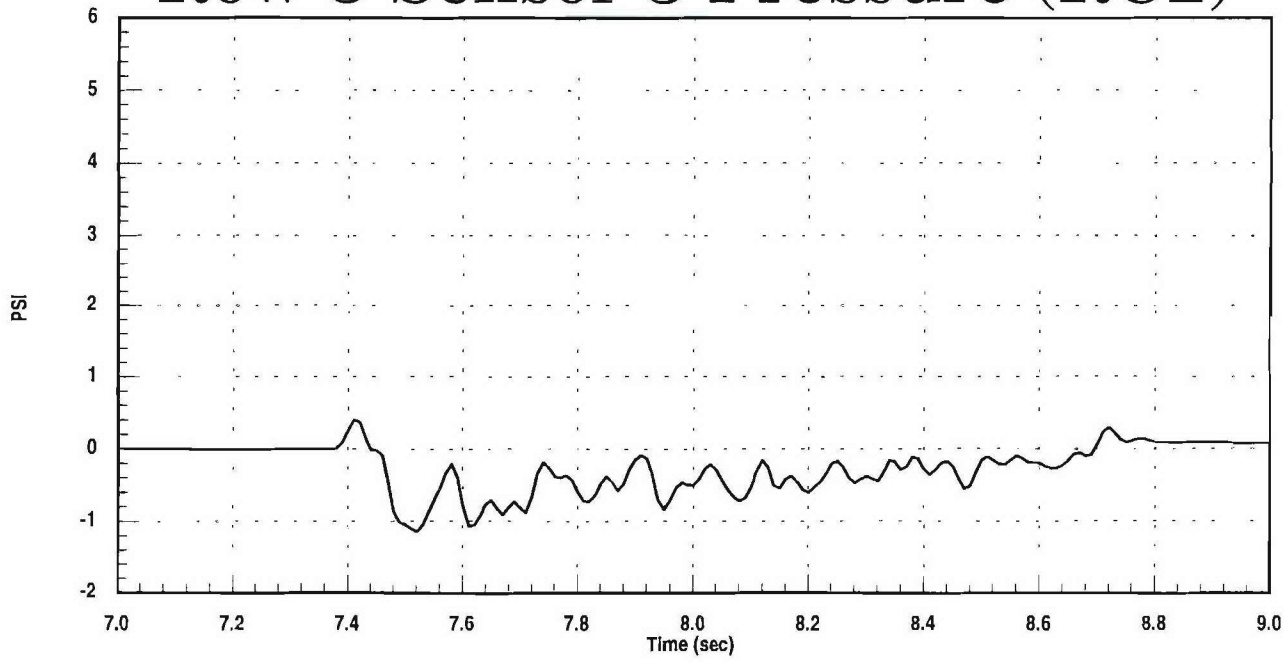
Row 3 Sensor 2 Pressure (LC2)



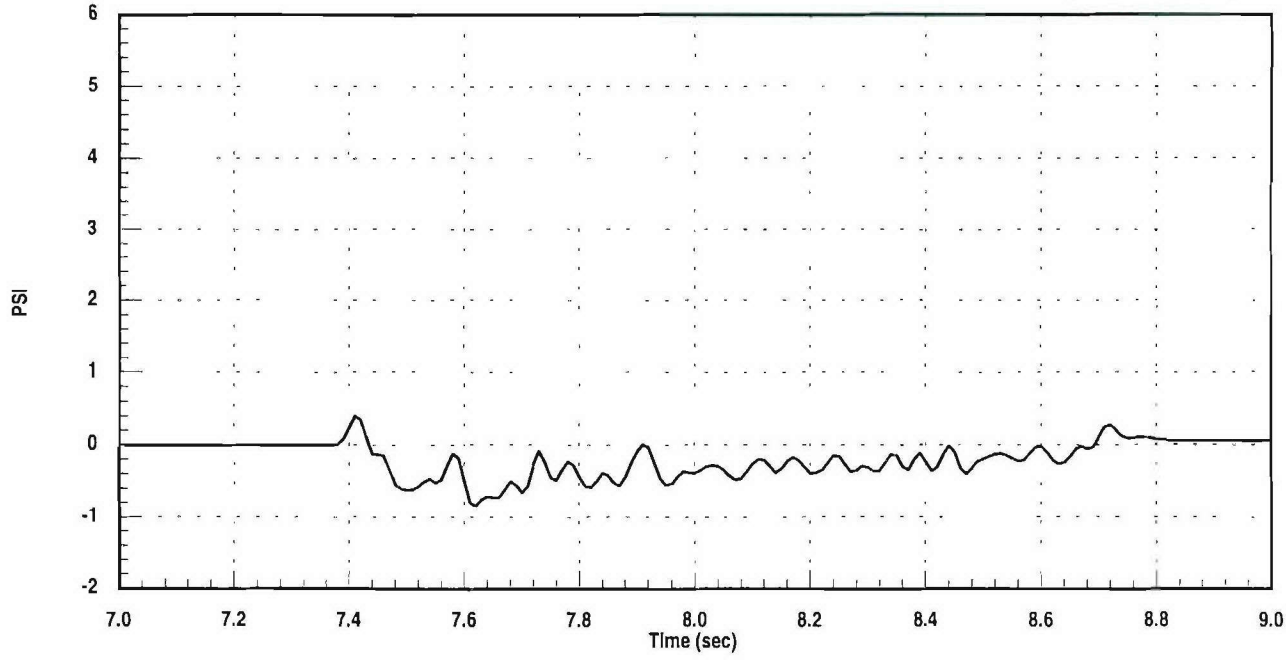
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



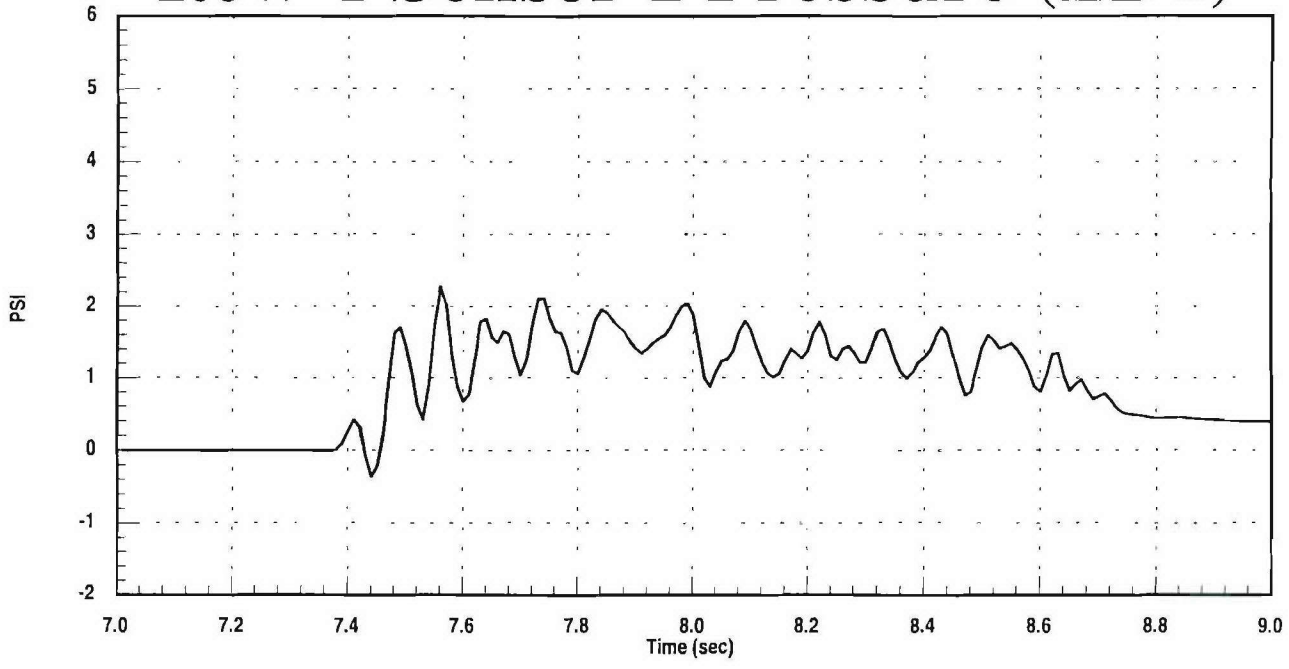
Row 3 Sensor 4 Pressure (RC1)



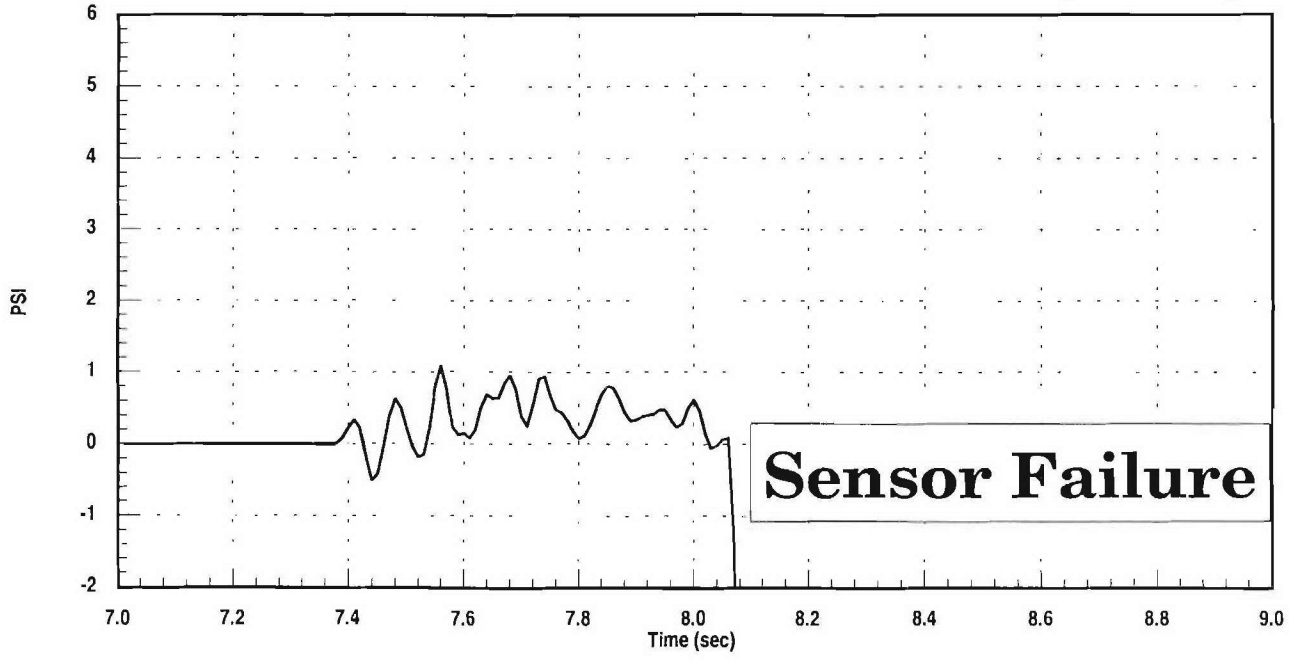
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



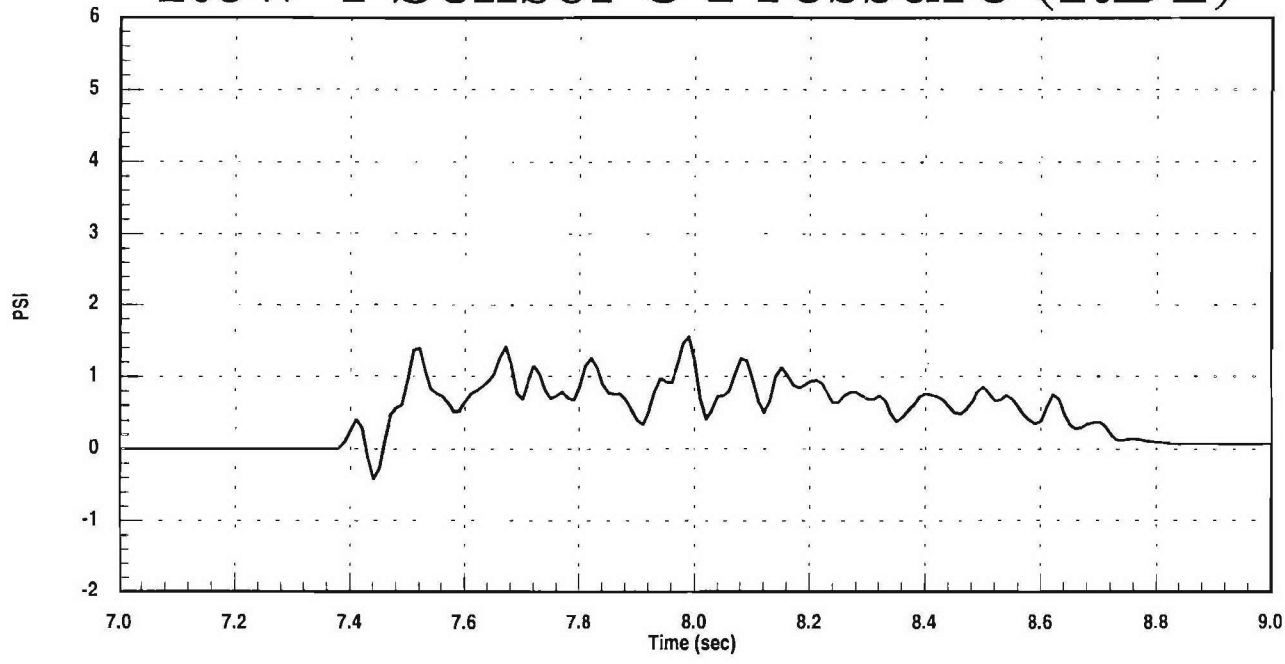
Row 4 Sensor 2 Pressure (LD2)



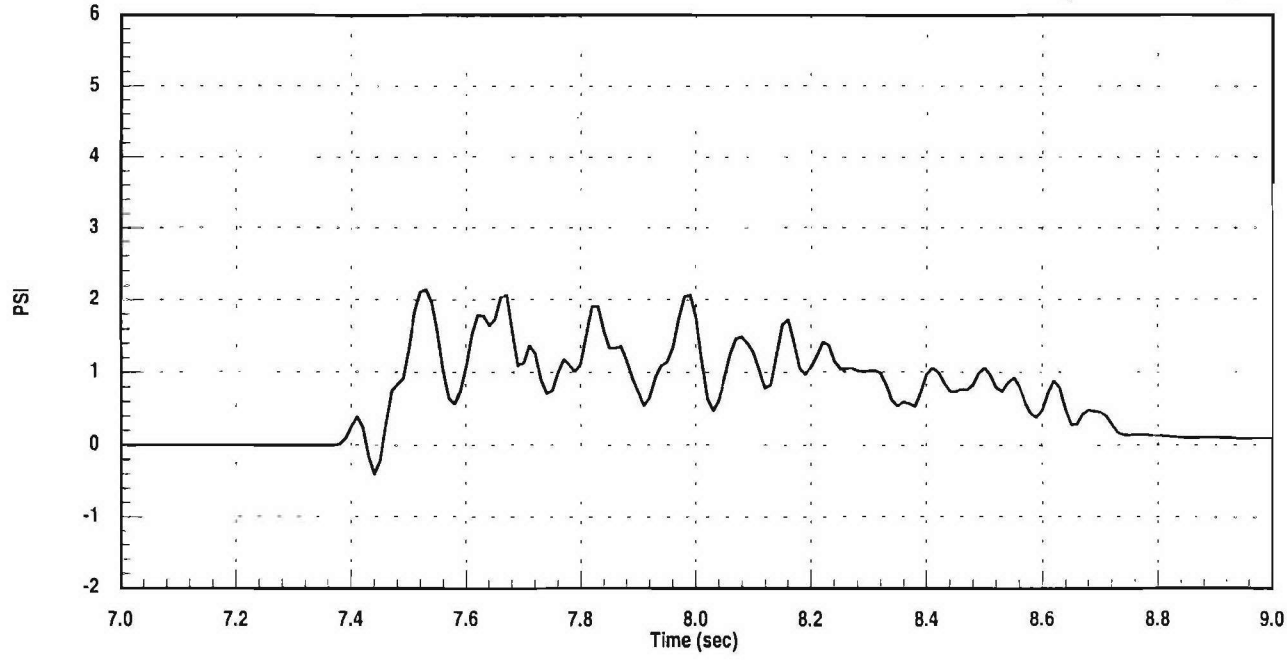
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



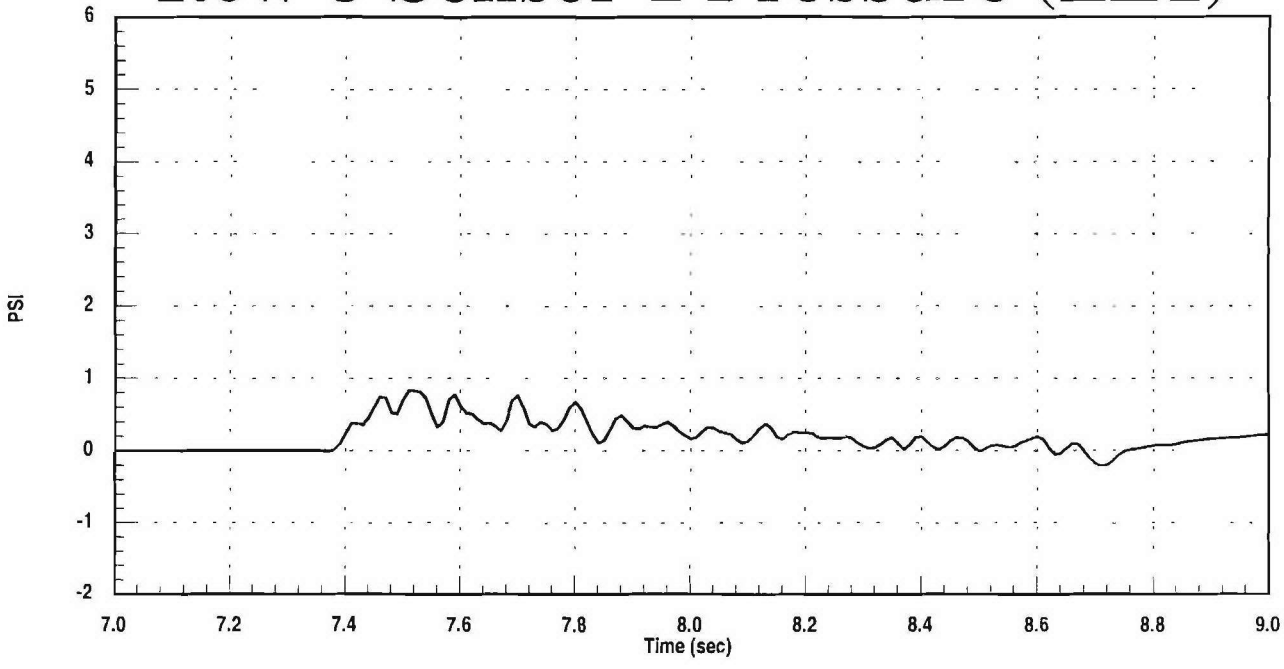
Row 4 Sensor 4 Pressure (RD1)



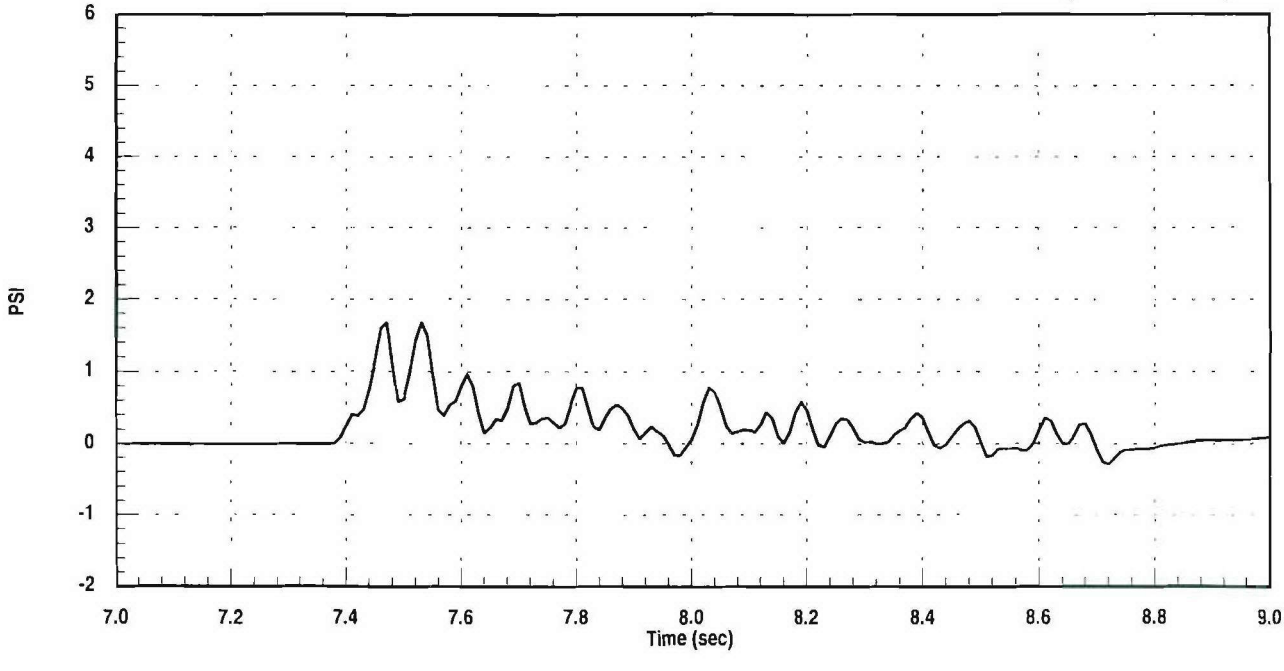
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



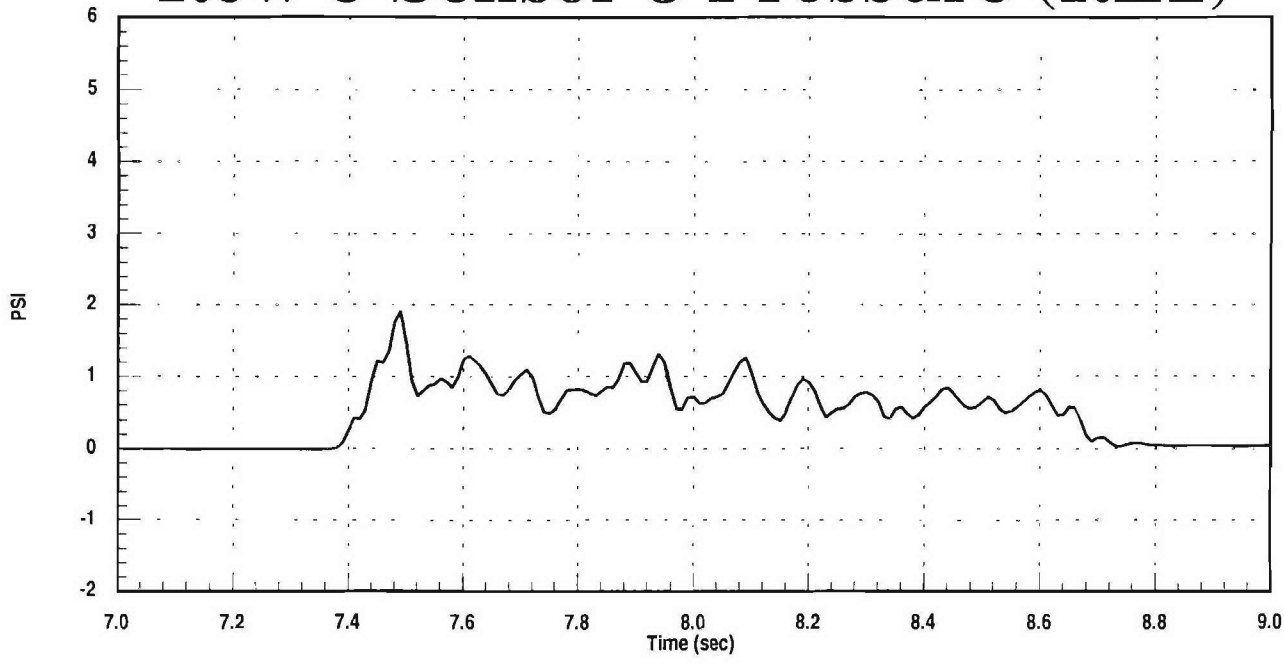
Row 5 Sensor 2 Pressure (LE2)



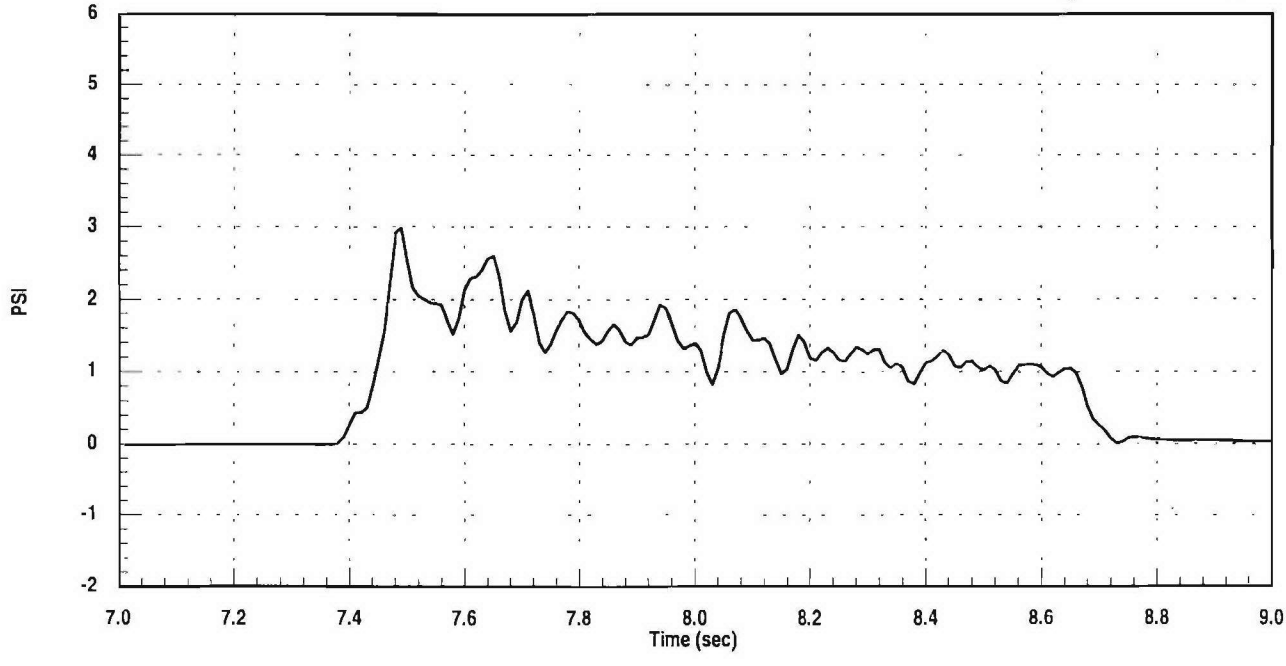
WD7, 450 KEAS

T-38 Pillar / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



E-80

WD8, 450 KEAS

Post / Torso Rake

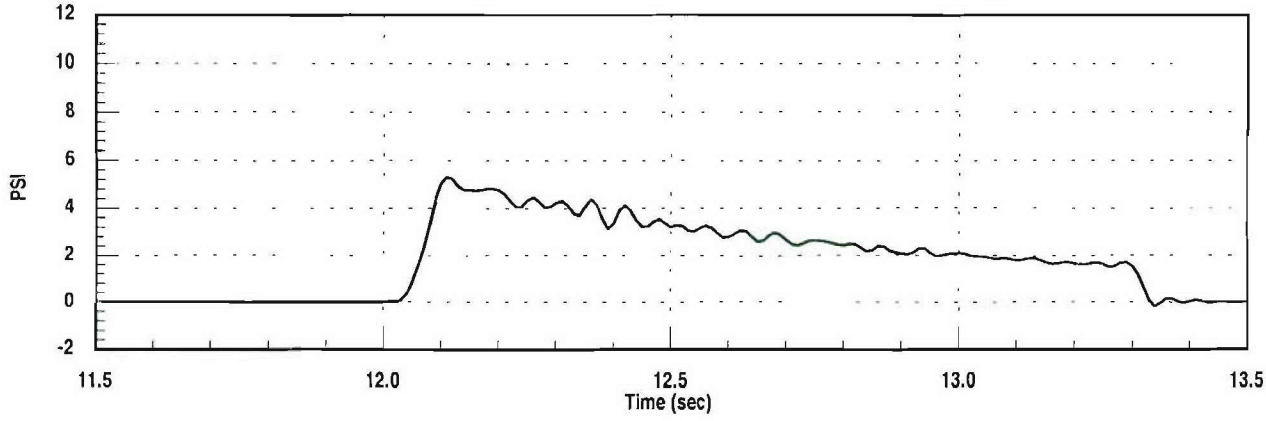
Processed Data

Main Rake Pressure	E-82
Row 1 Sensor 1 & 2 Pressures	E-83
Row 1 Sensor 3 & 4 Pressures	E-84
Row 2 Sensor 1 & 2 Pressures	E-85
Row 2 Sensor 3 & 4 Pressures	E-86
Row 3 Sensor 1 & 2 Pressures	E-87
Row 3 Sensor 3 & 4 Pressures	E-88
Row 4 Sensor 1 & 2 Pressures	E-89
Row 4 Sensor 3 & 4 Pressures	E-90
Row 5 Sensor 1 & 2 Pressures	E-91
Row 5 Sensor 3 & 4 Pressures	E-92

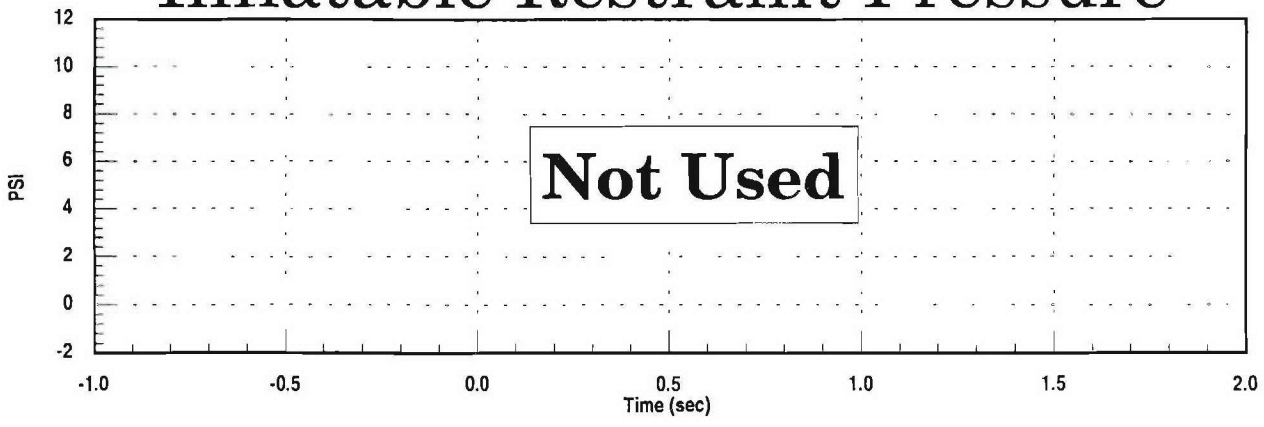
WD8, 450 KEAS

Post / Torso Rake

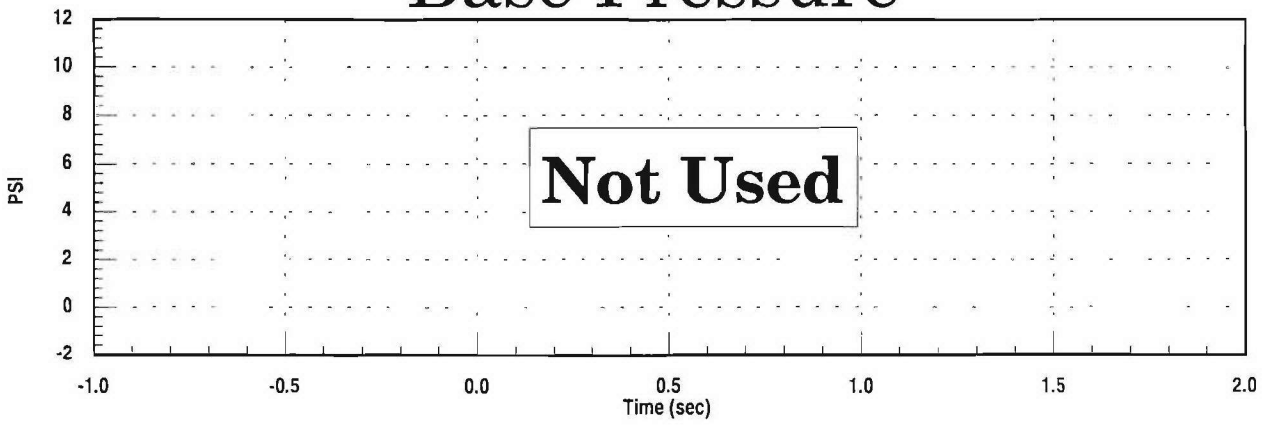
Main Rake Pressure



Inflatable Restraint Pressure



Base Pressure

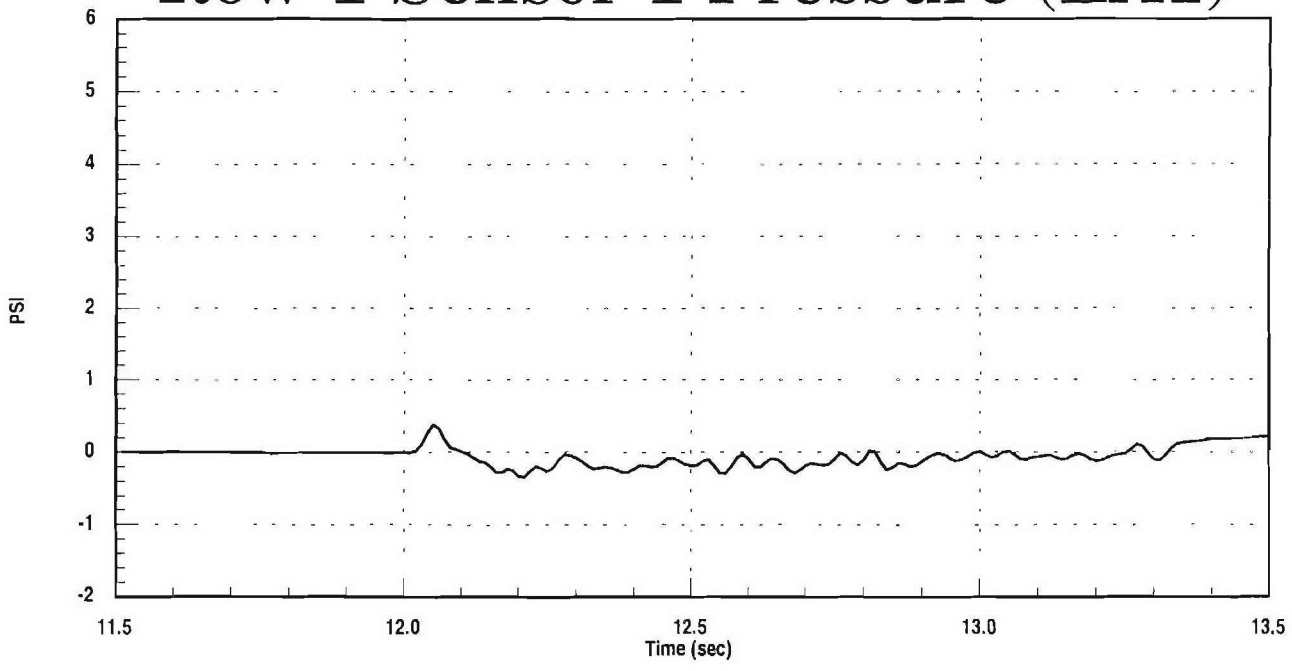


E-82

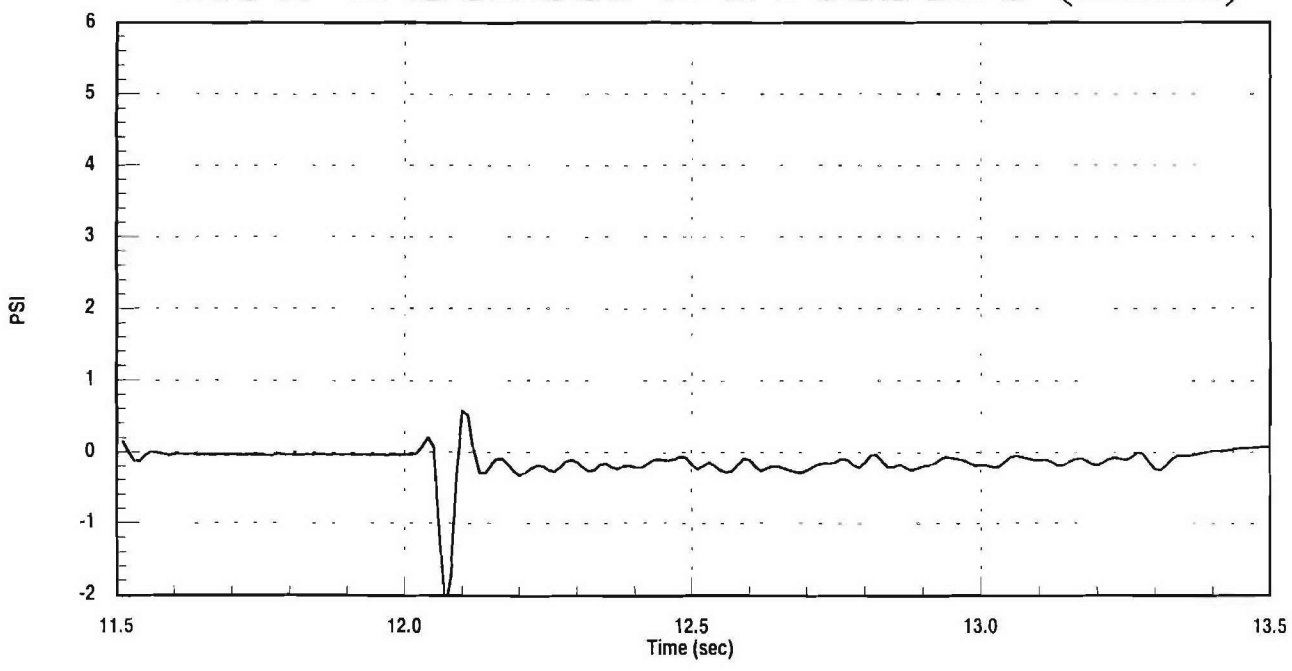
WD8, 450 KEAS

Post / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



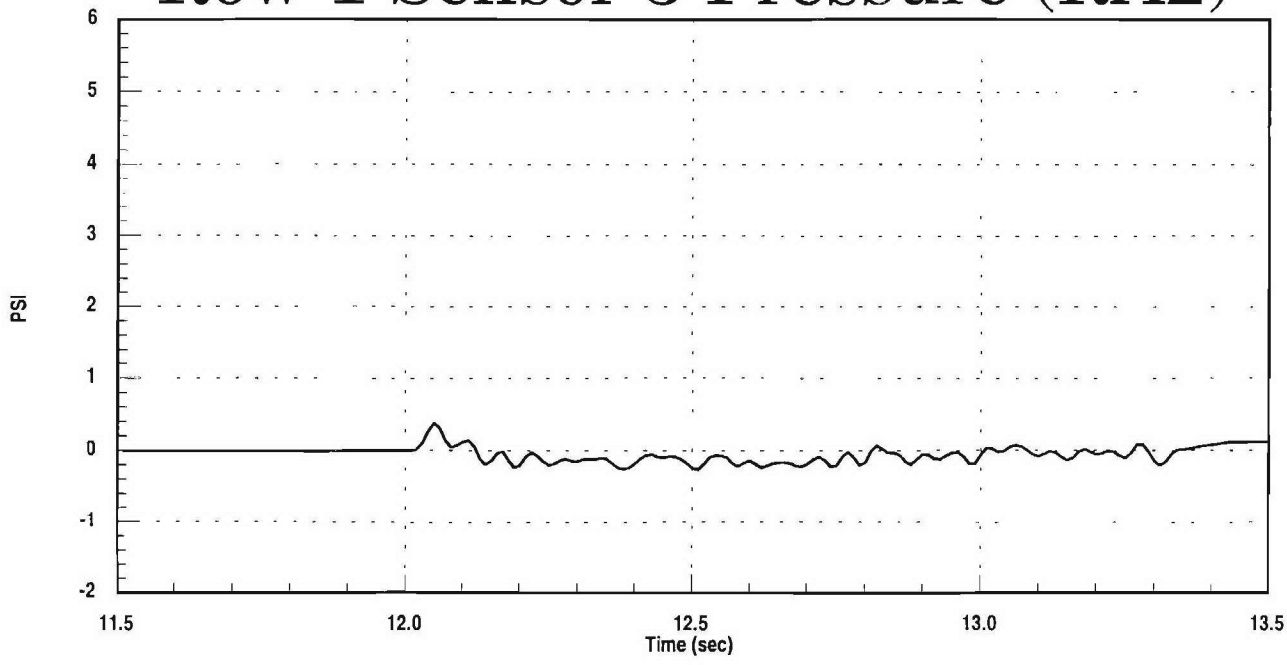
Row 1 Sensor 2 Pressure (LA2)



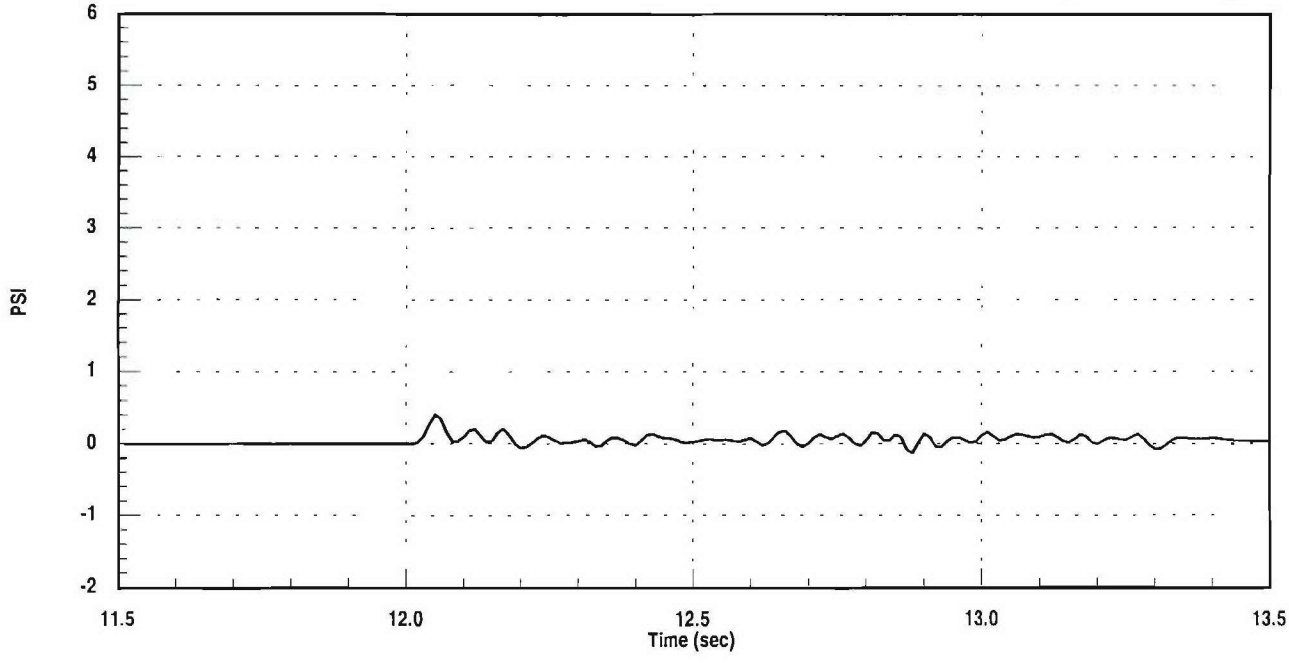
WD8, 450 KEAS

Post / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



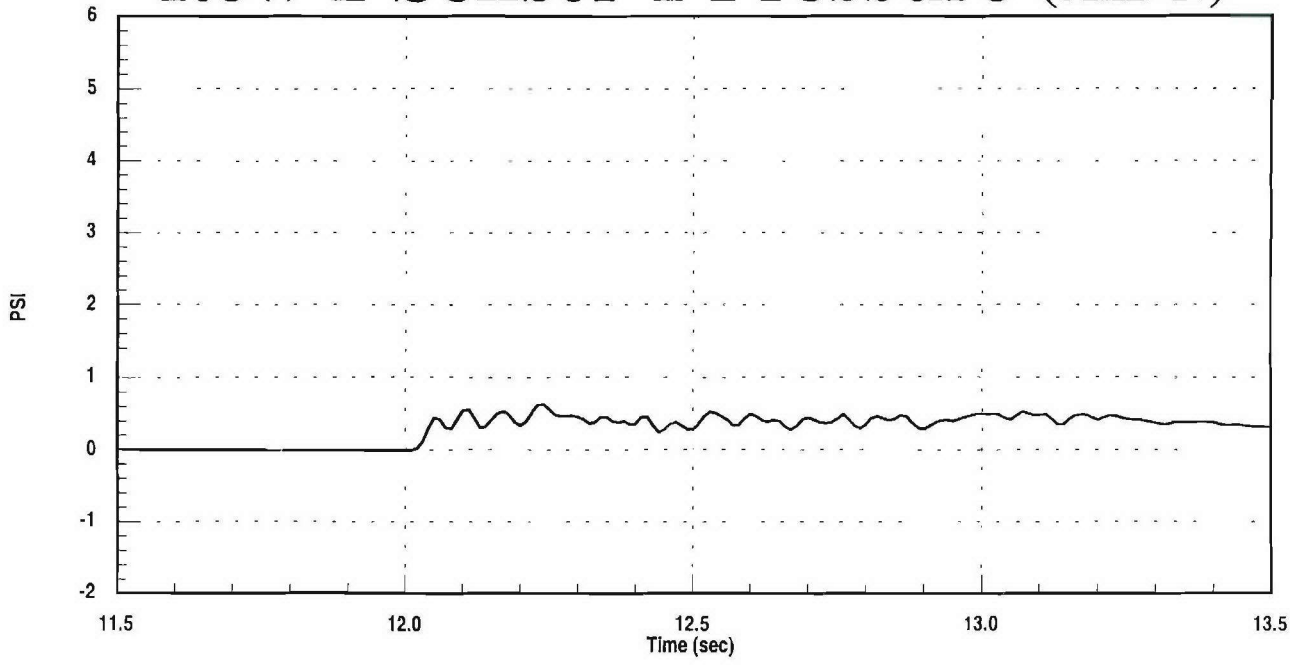
Row 1 Sensor 4 Pressure (RA1)



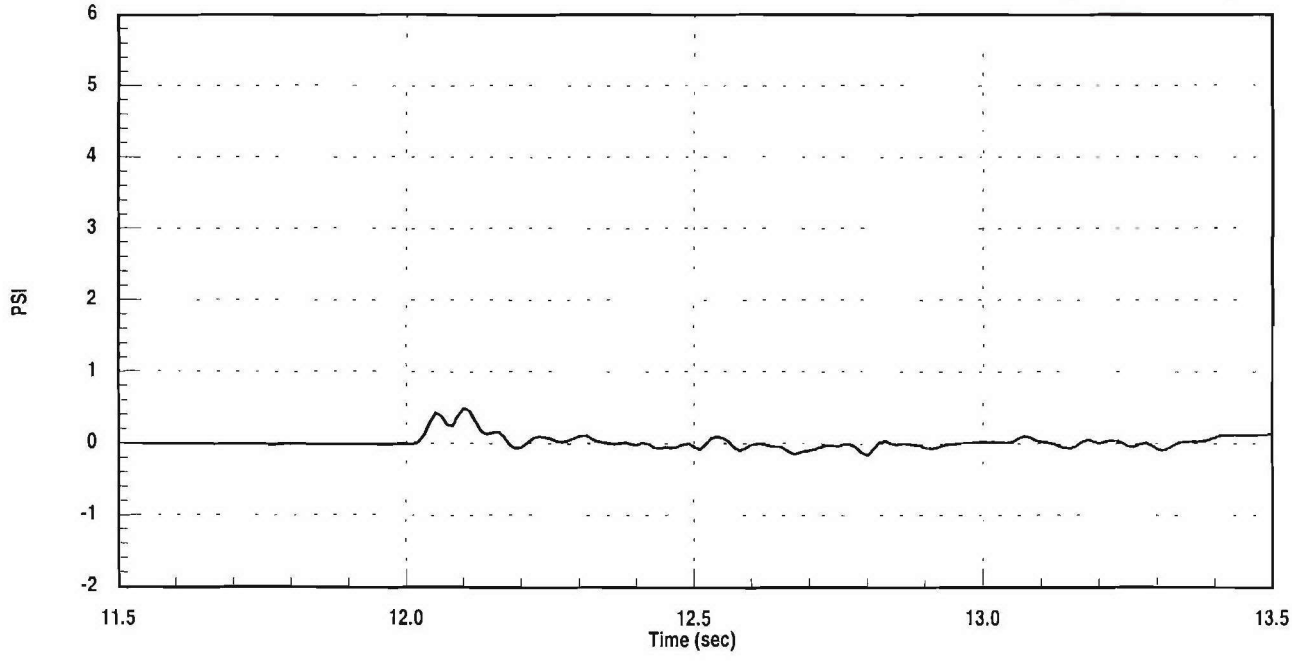
WD8, 450 KEAS

Post / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



Row 2 Sensor 2 Pressure (LB2)

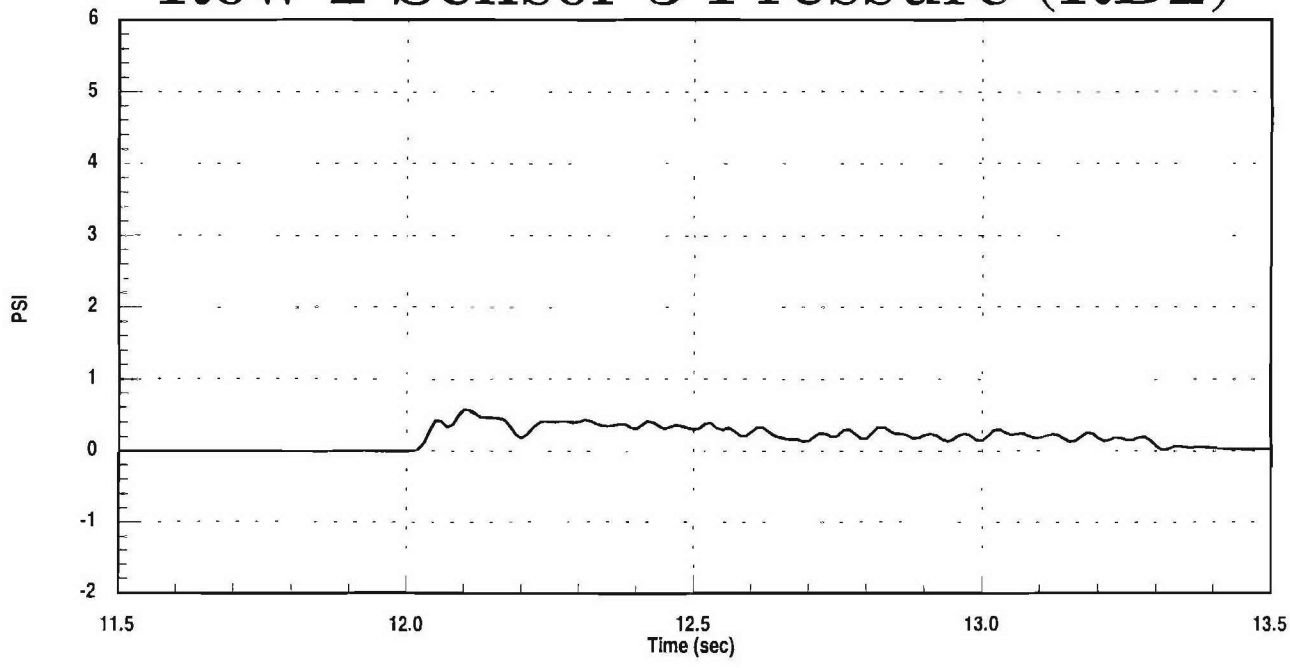


E-85

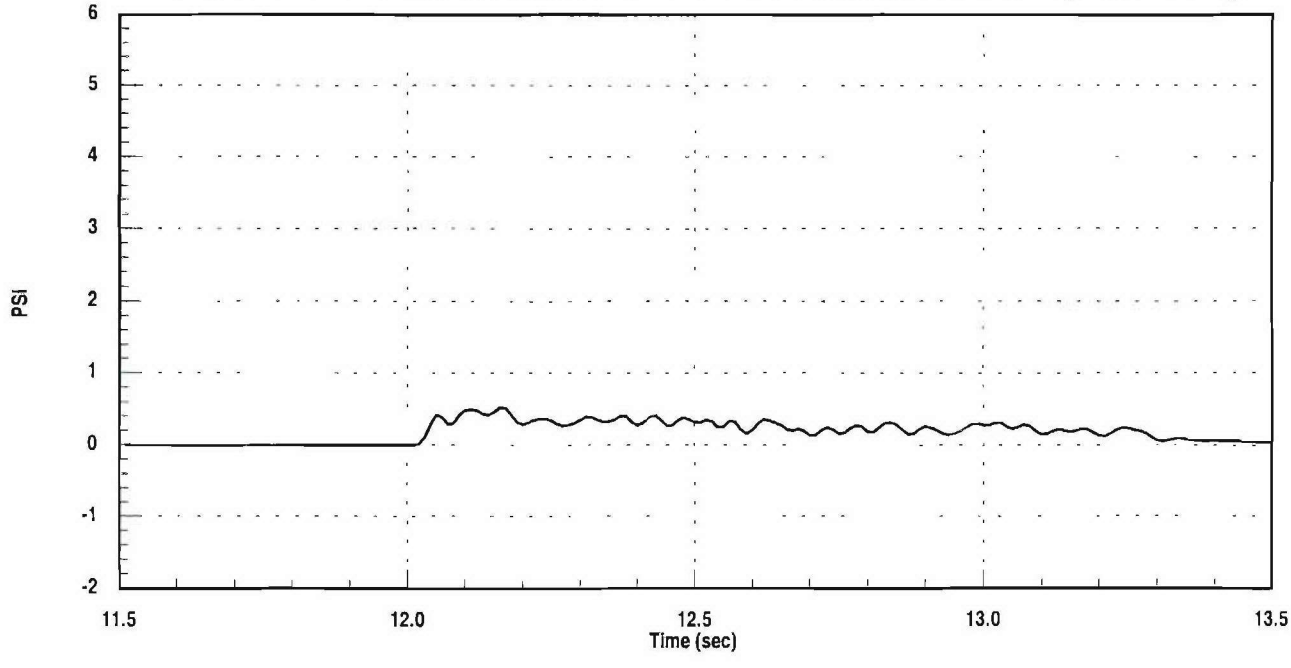
WD8, 450 KEAS

Post / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



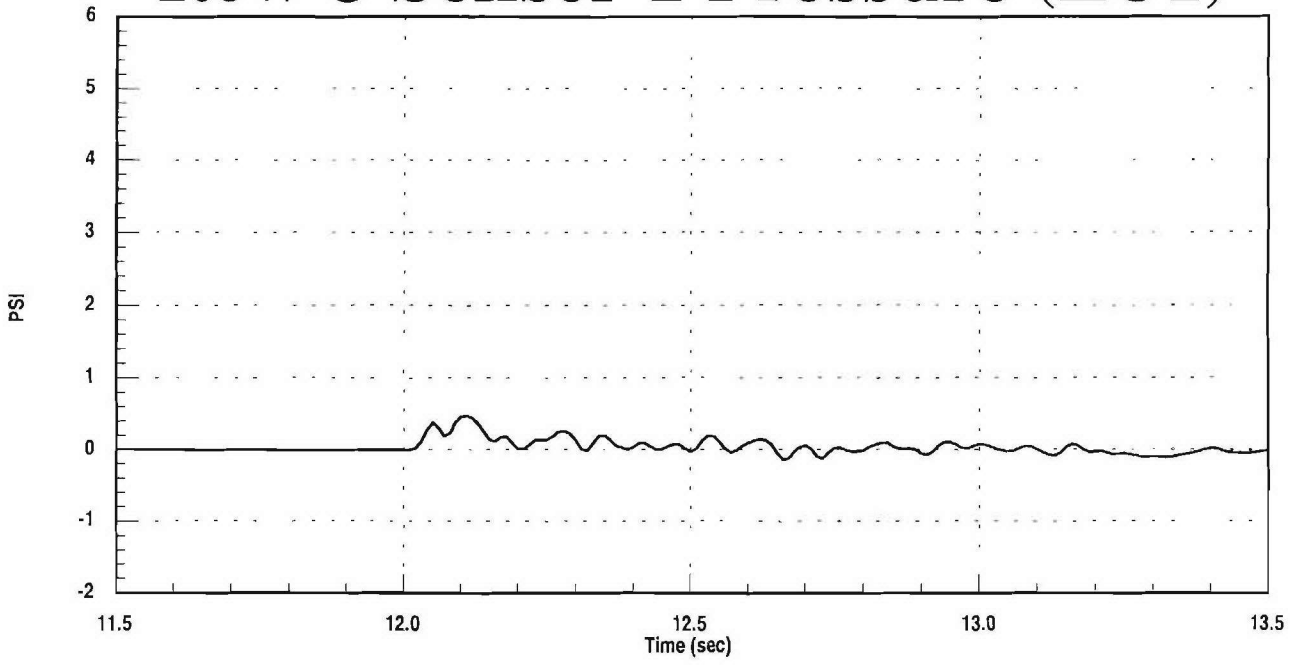
Row 2 Sensor 4 Pressure (RB1)



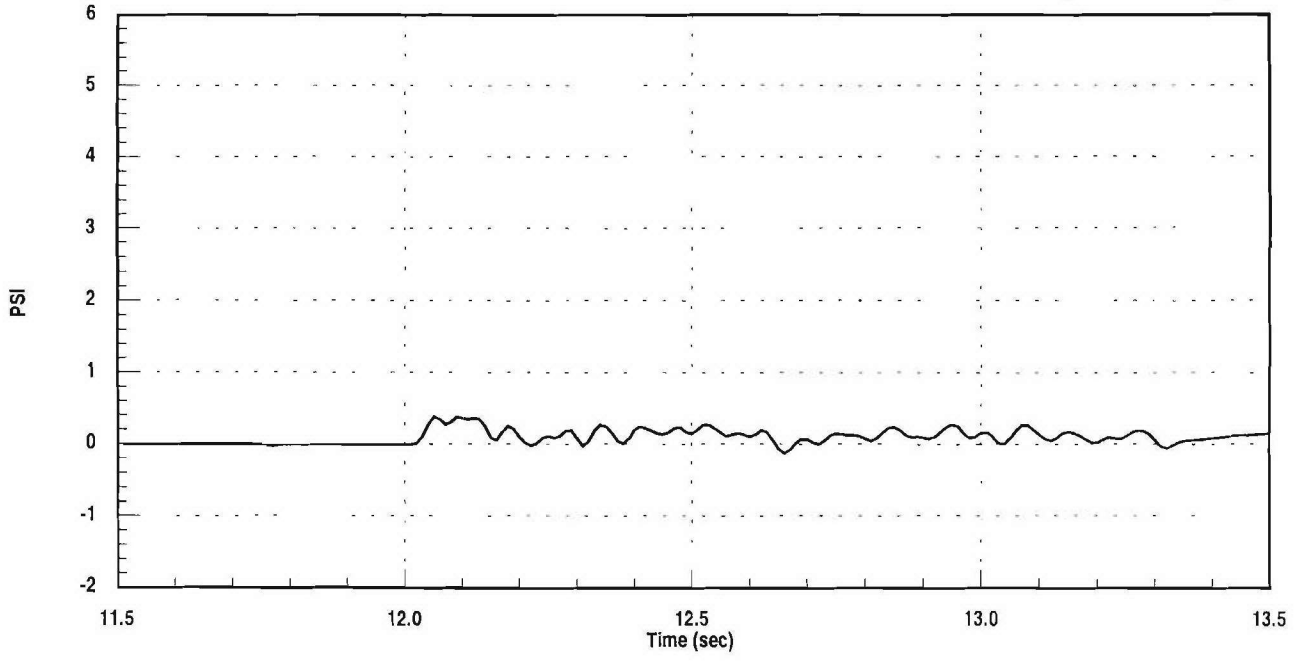
WD8, 450 KEAS

Post / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



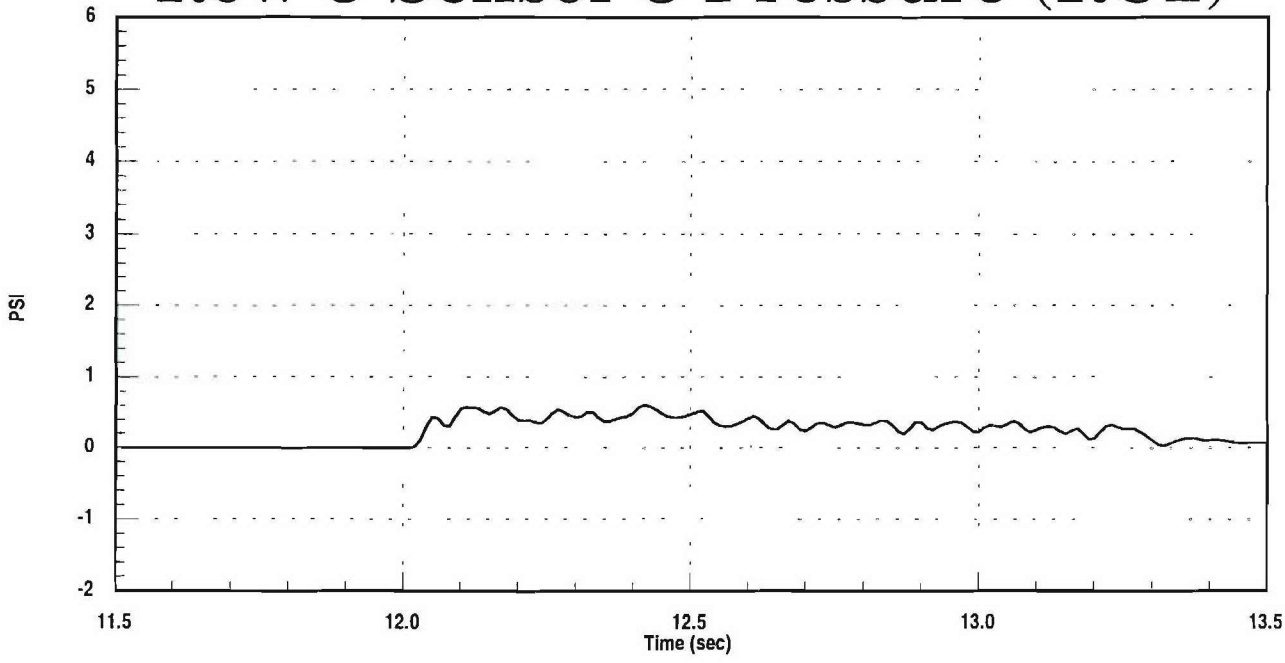
Row 3 Sensor 2 Pressure (LC2)



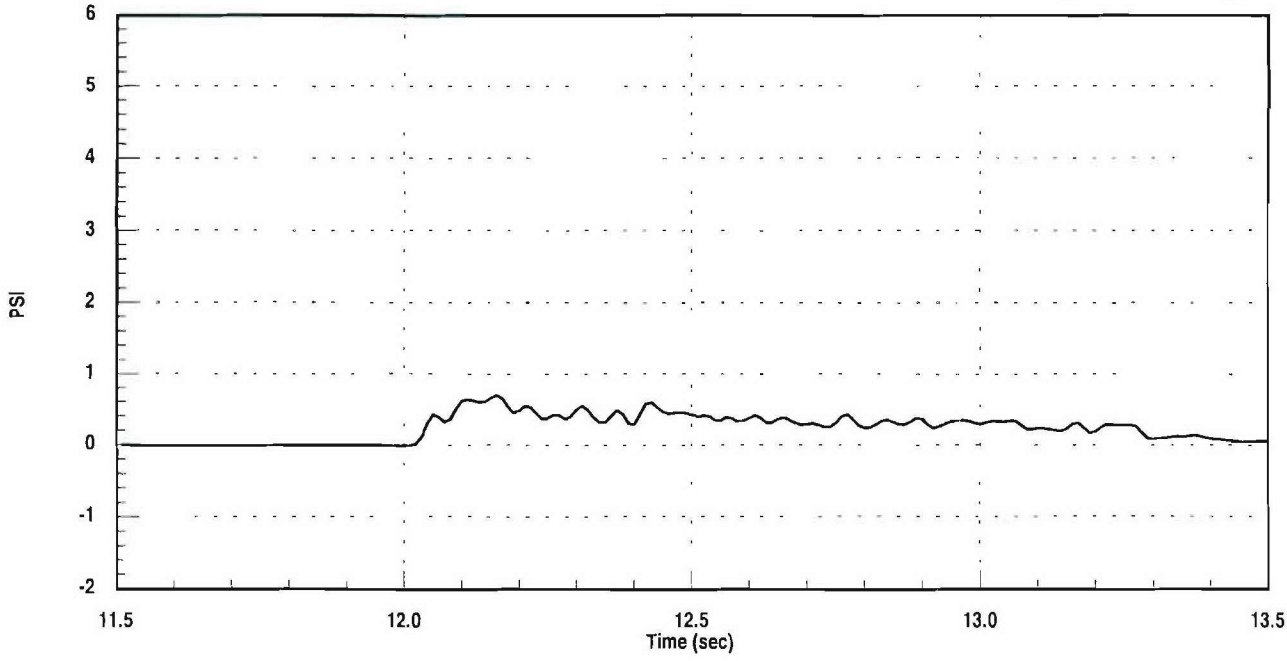
WD8, 450 KEAS

Post / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



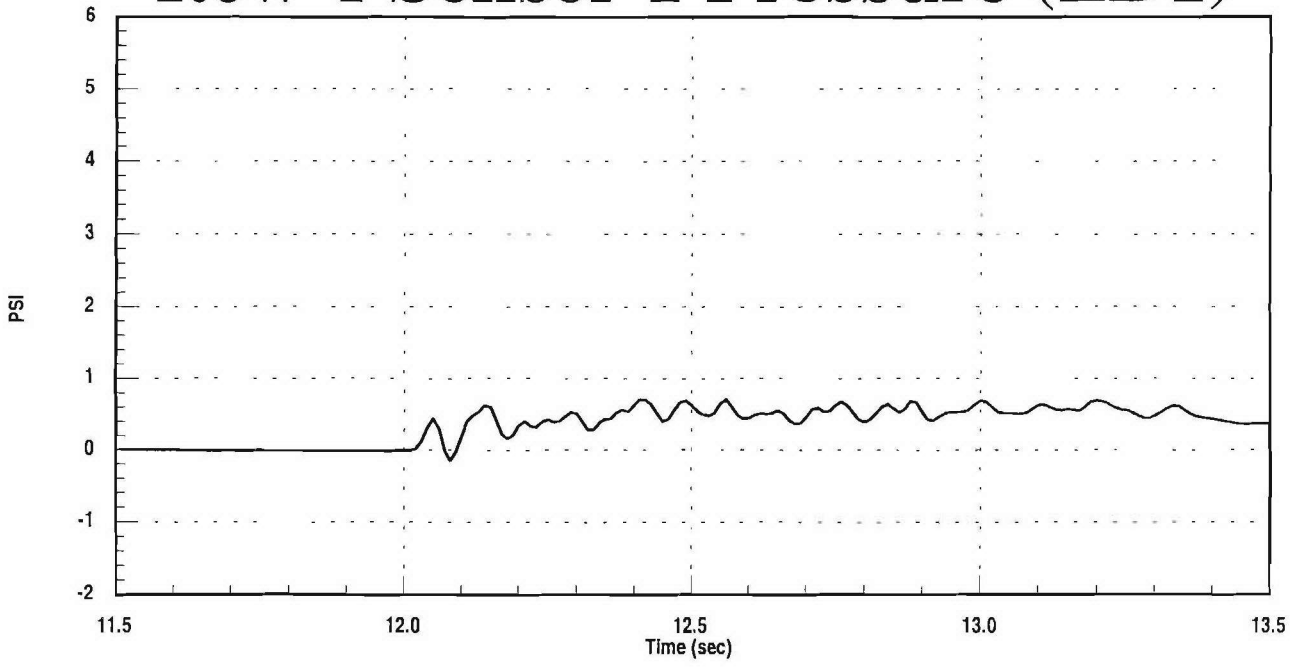
Row 3 Sensor 4 Pressure (RC1)



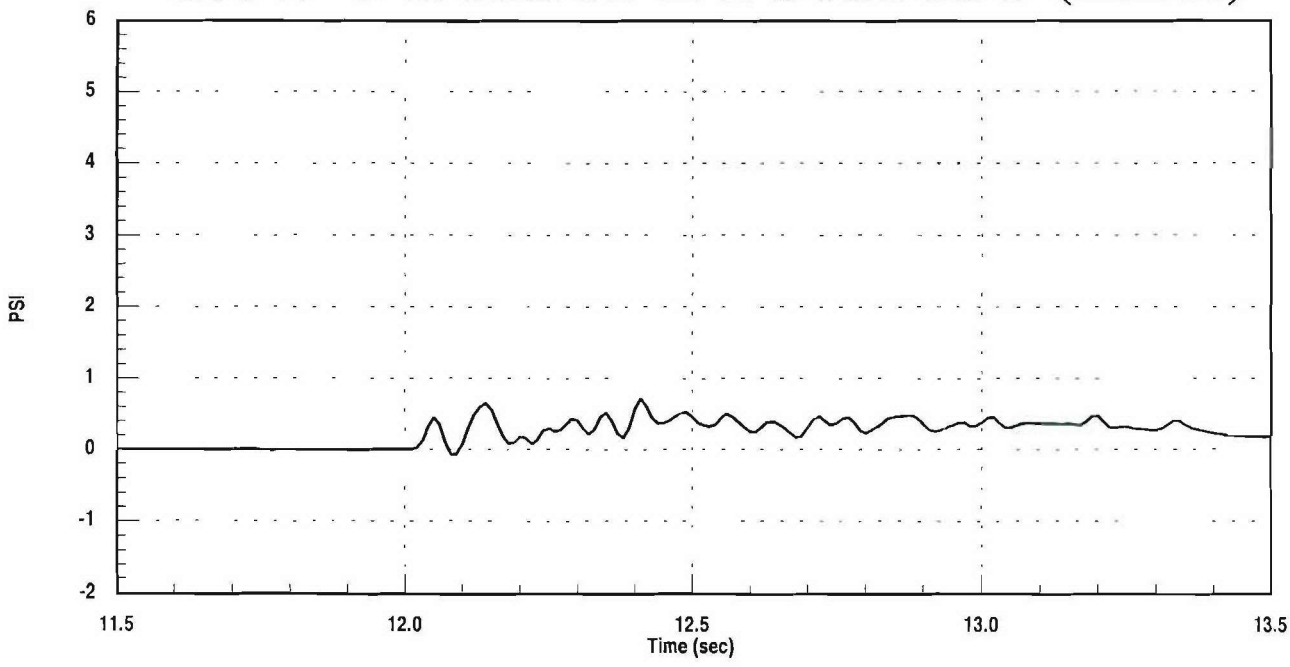
WD8, 450 KEAS

Post / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



Row 4 Sensor 2 Pressure (LD2)

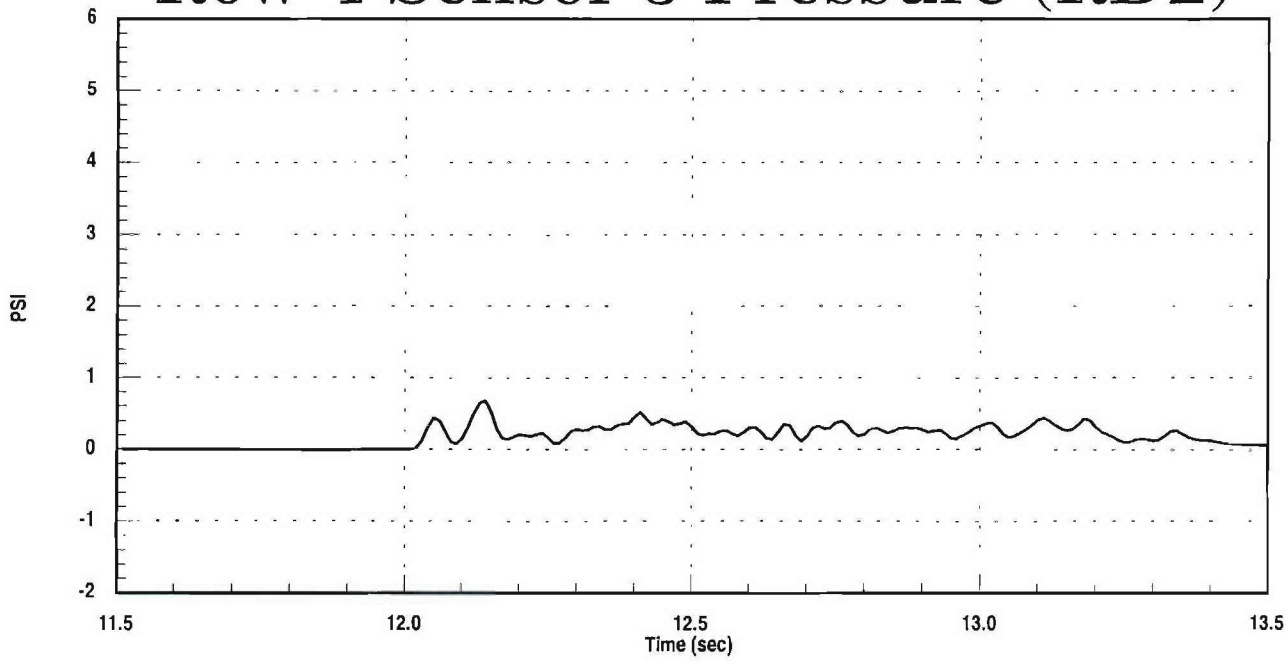


E-89

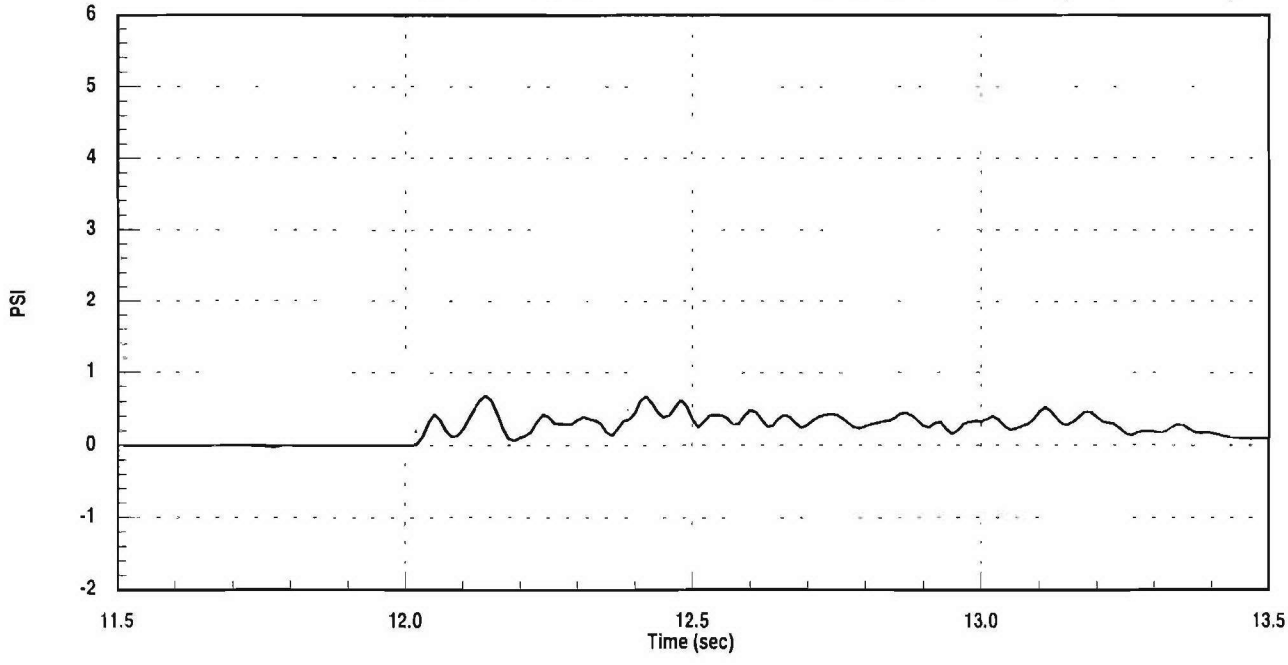
WD8, 450 KEAS

Post / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



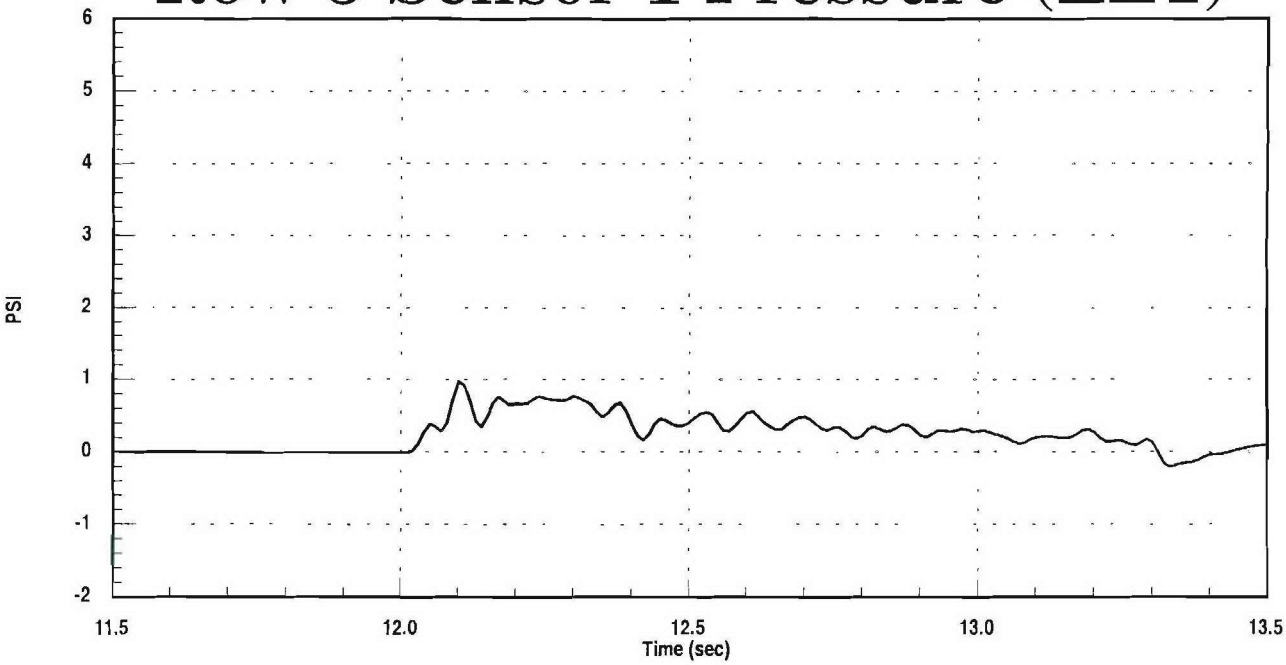
Row 4 Sensor 4 Pressure (RD1)



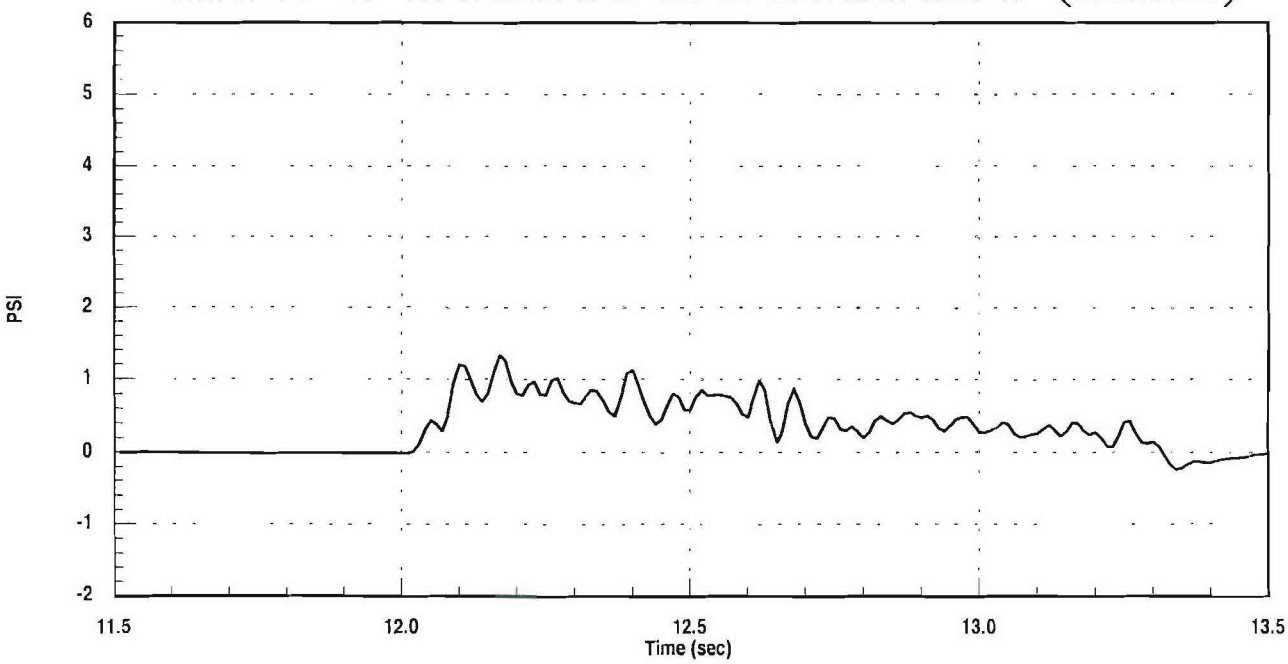
WD8, 450 KEAS

Post / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



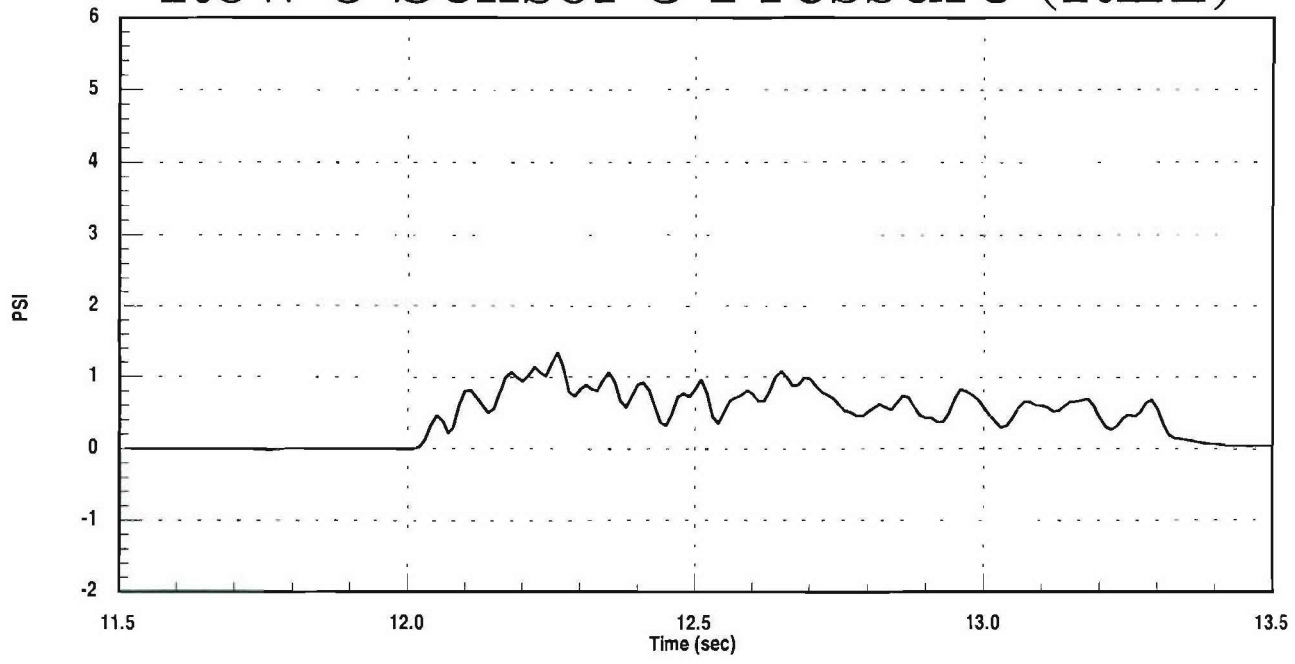
Row 5 Sensor 2 Pressure (LE2)



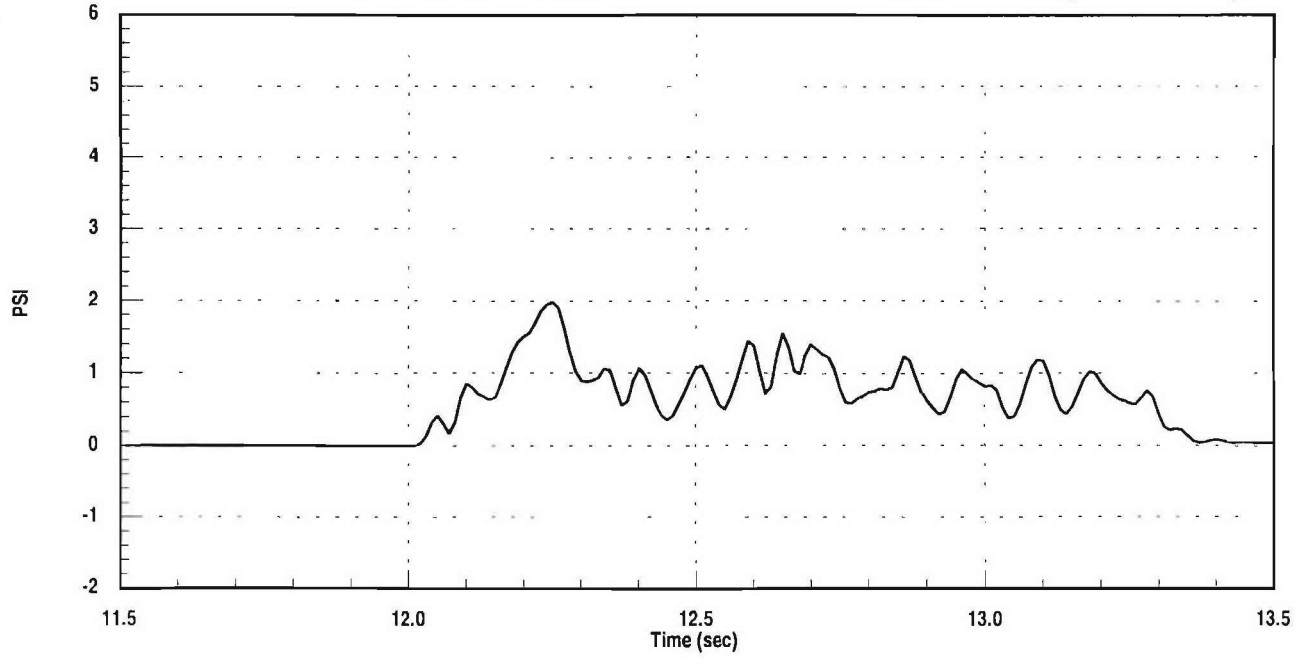
WD8, 450 KEAS

Post / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



E-92

WD9, 575 KEAS

T-38 Pillar / Hybrid III

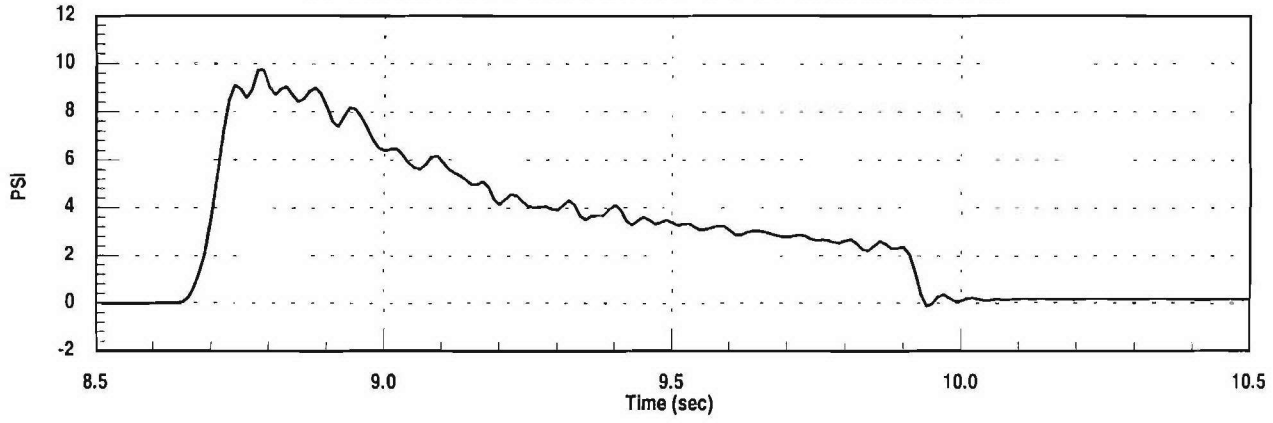
Processed Data

Main Rake, Inflatable Restraint Inner Pressures E-94
Neck Forces E-95
Neck Moments E-96

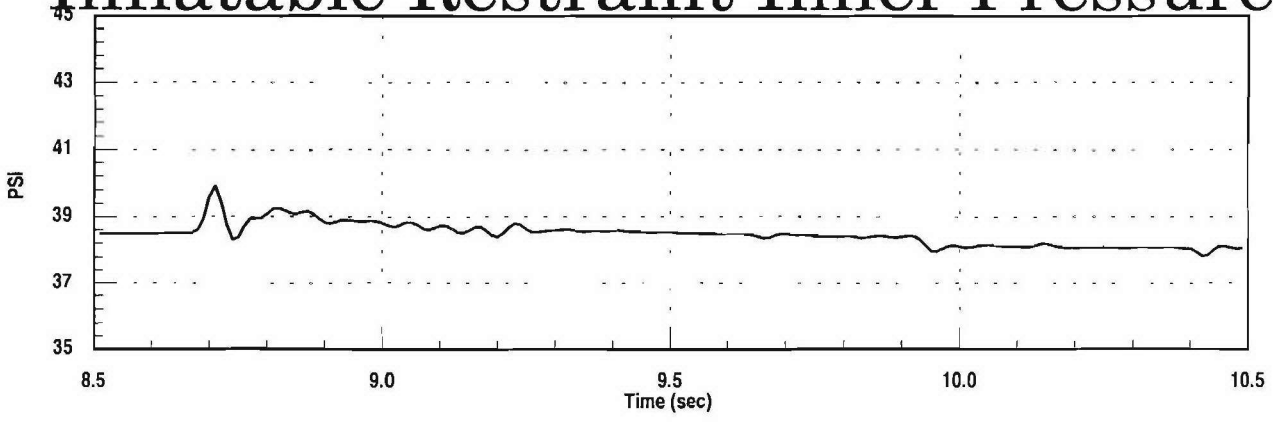
WD9, 575 KEAS

T-38 Pillar / Hybrid III

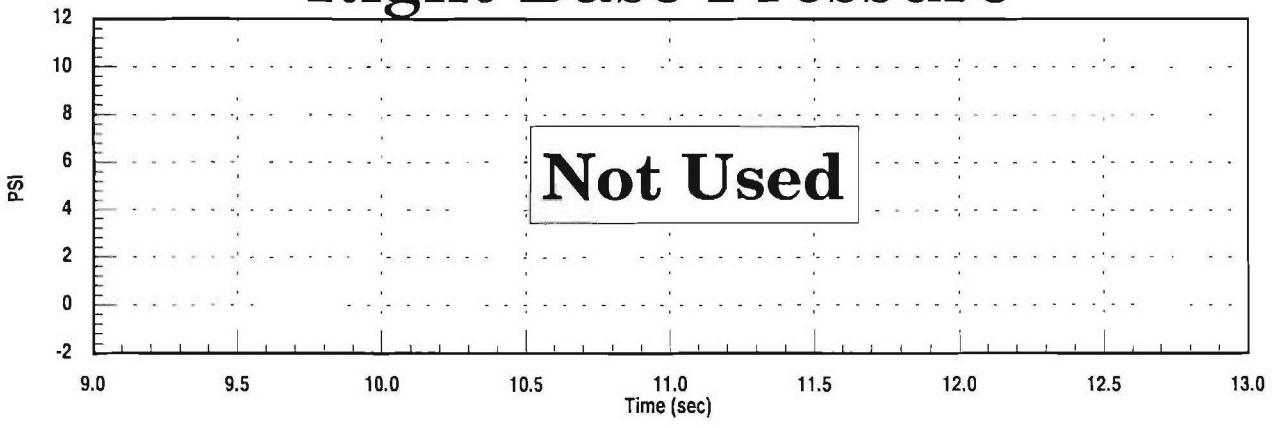
Main Rake Pressure



Inflatable Restraint Inner Pressure



Right Base Pressure

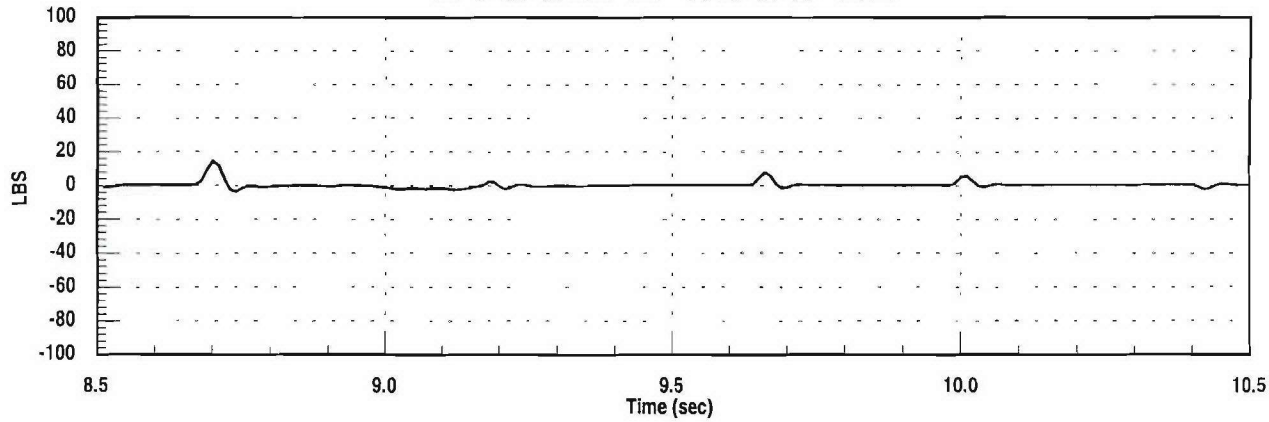


E-94

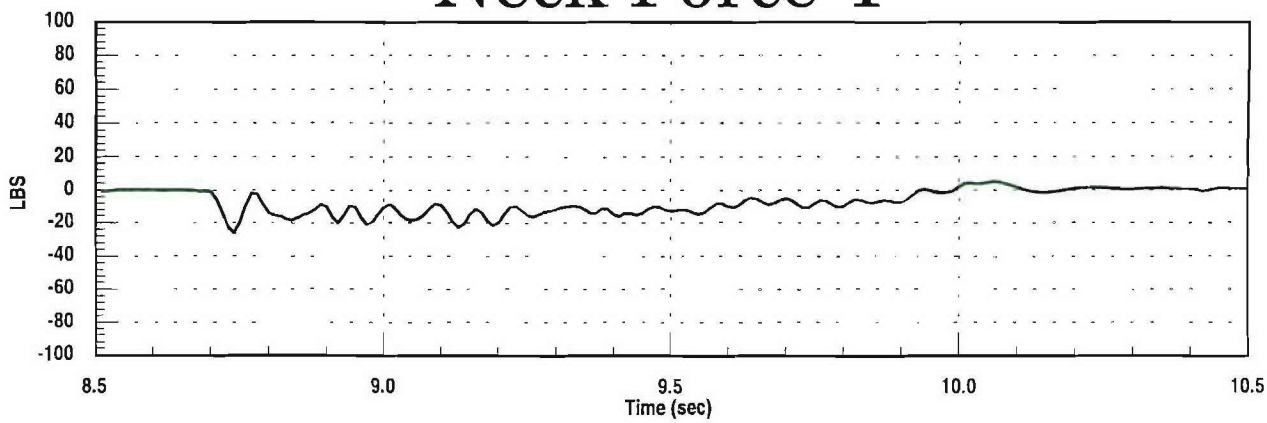
WD9, 575 KEAS

T-38 Pillar / Hybrid III

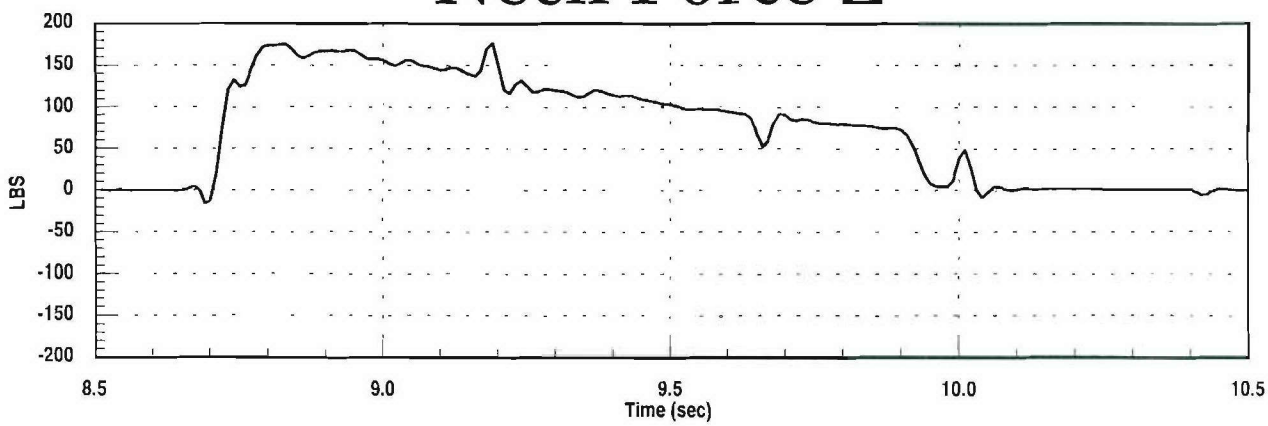
Neck Force X



Neck Force Y



Neck Force Z

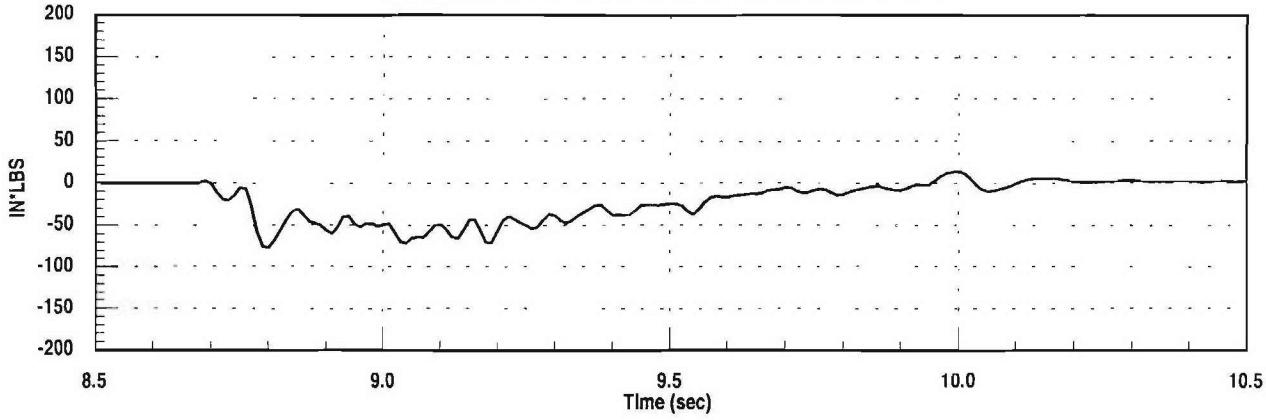


E-95

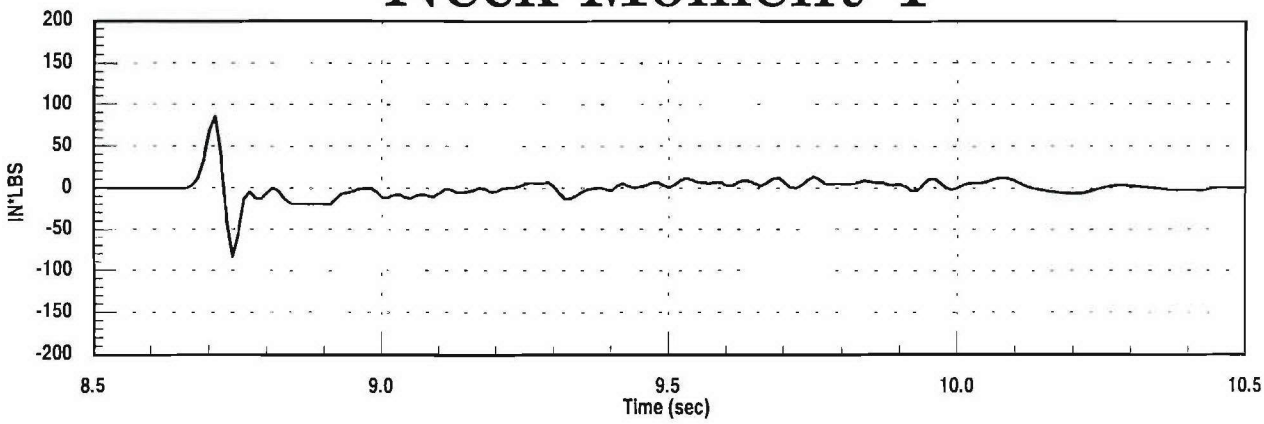
WD9, 575 KEAS

T-38 Pillar / Hybrid III

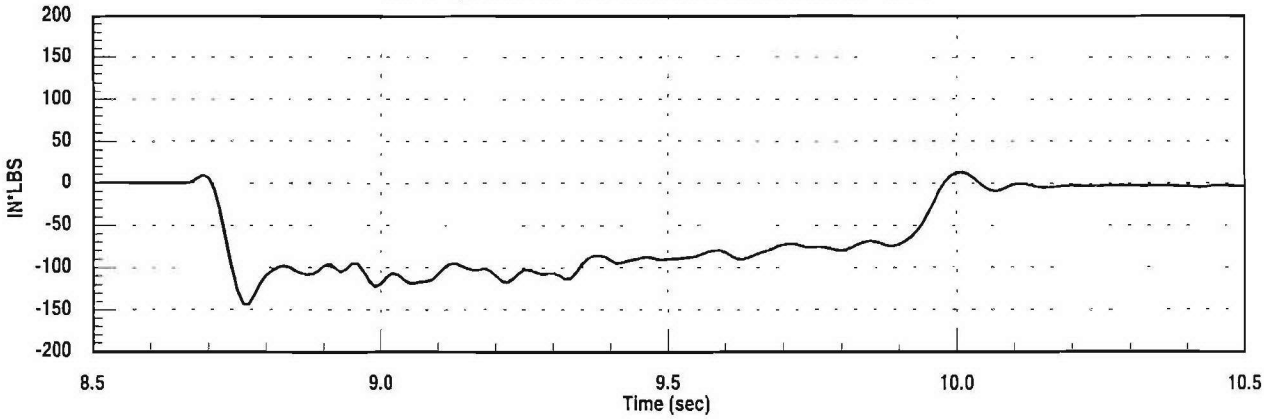
Neck Moment X



Neck Moment Y



Neck Moment Z



E-96

WD10, 575 KEAS

Post / Hybrid III

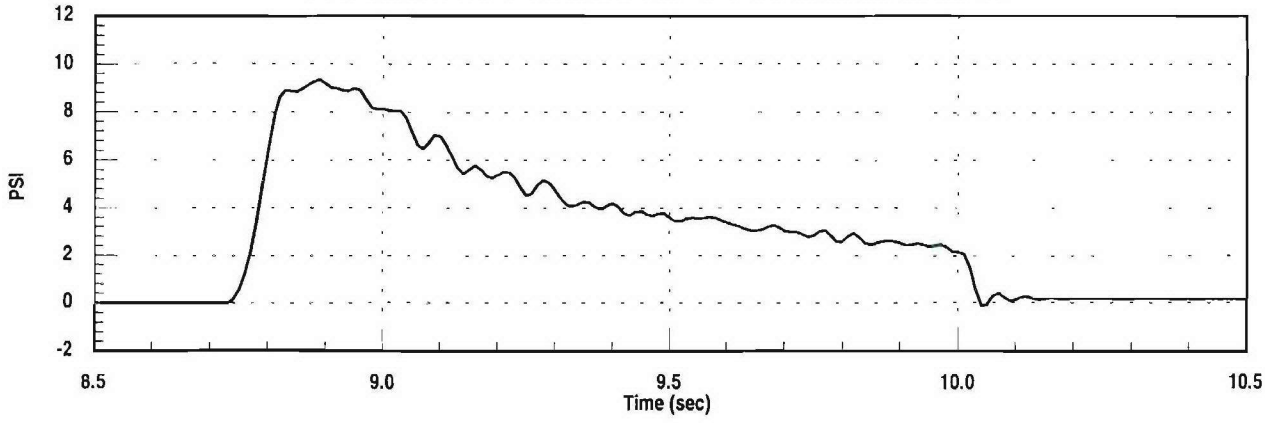
Processed Data

Main Rake Pressures	E-98
Neck Forces	E-99
Neck Moments	E-100

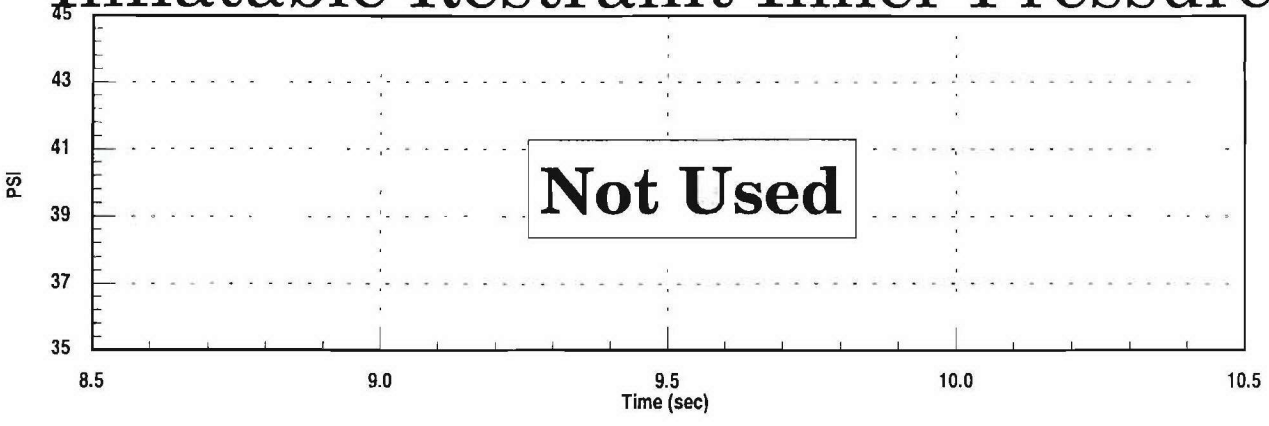
WD10, 575 KEAS

Post / Hybrid III

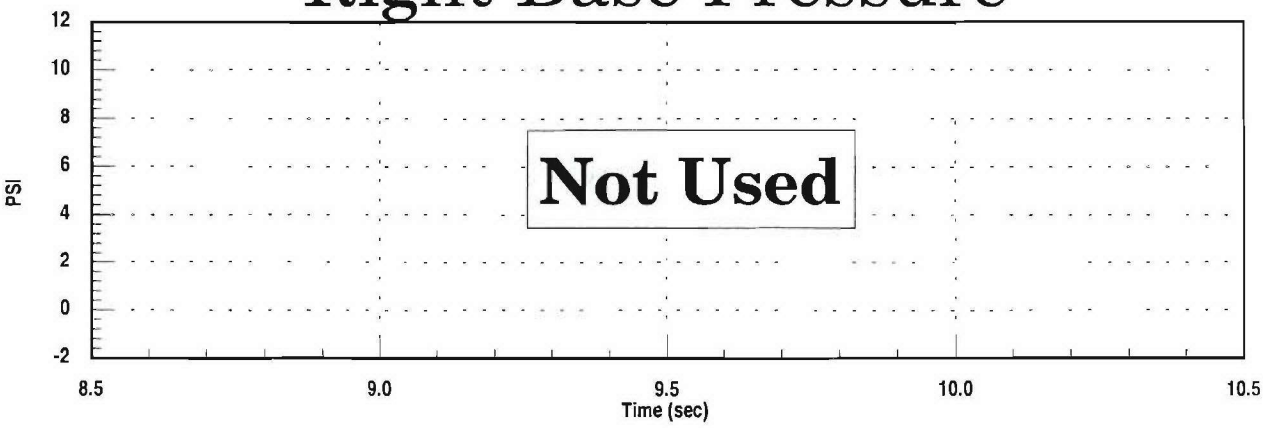
Main Rake Pressure



Inflatable Restraint Inner Pressure



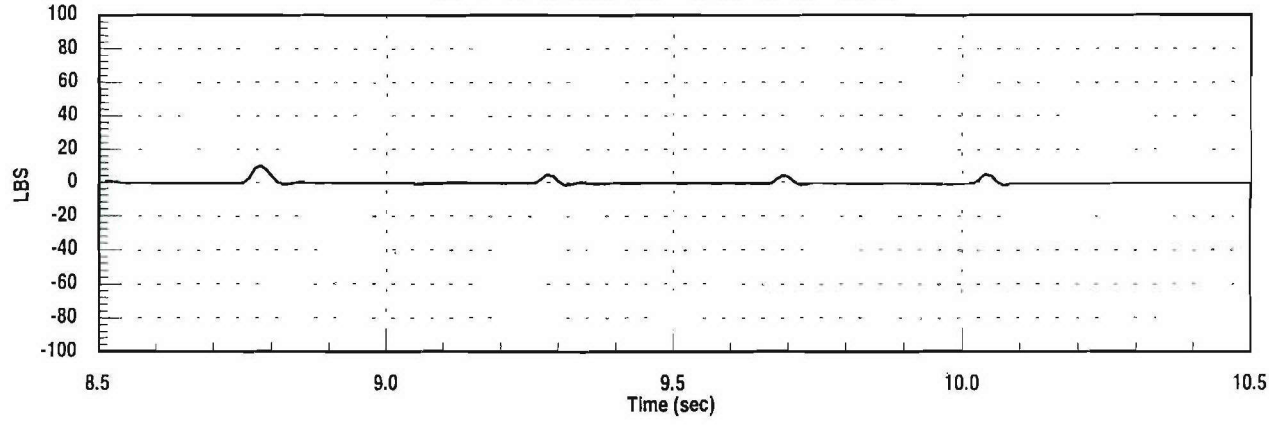
Right Base Pressure



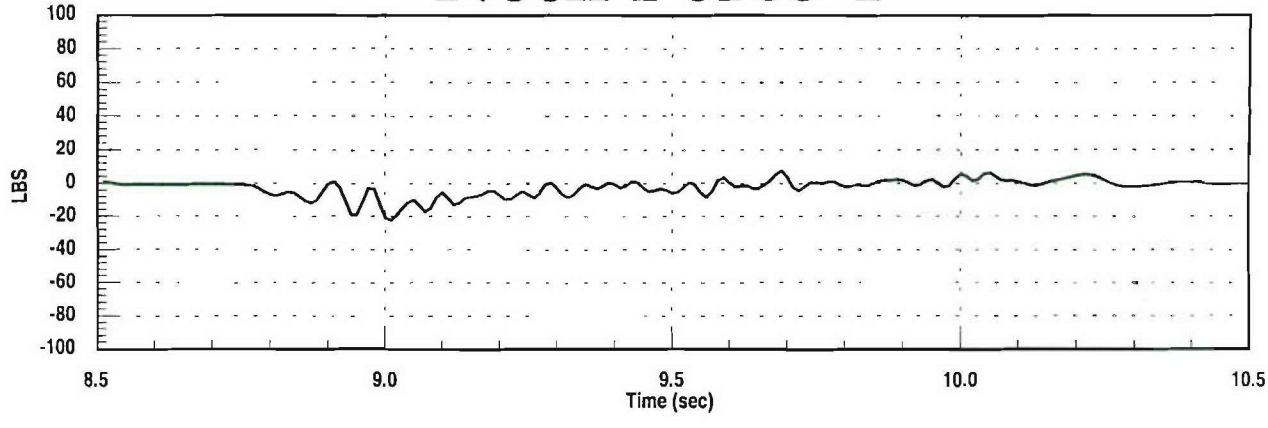
WD10, 575 KEAS

Post / Hybrid III

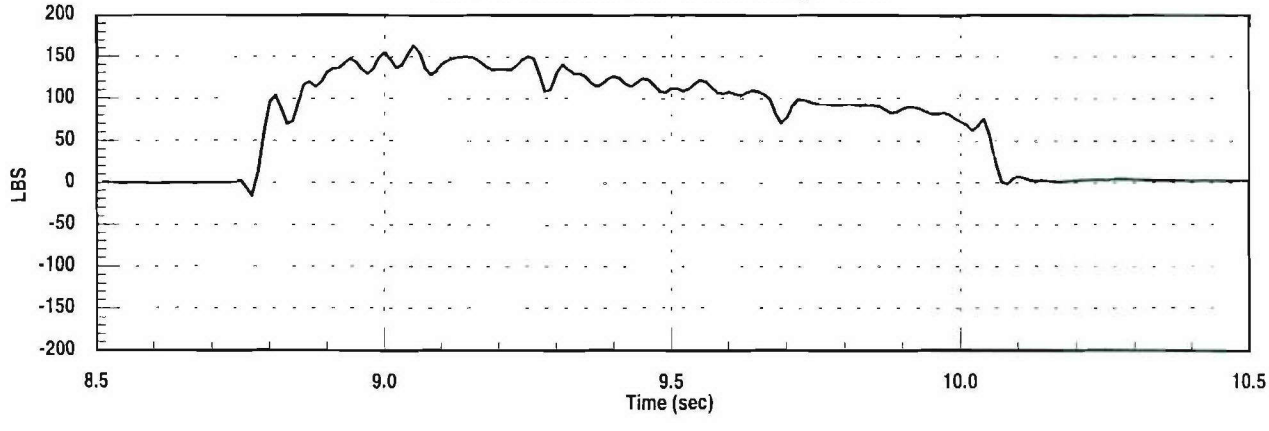
Neck Force X



Neck Force Y



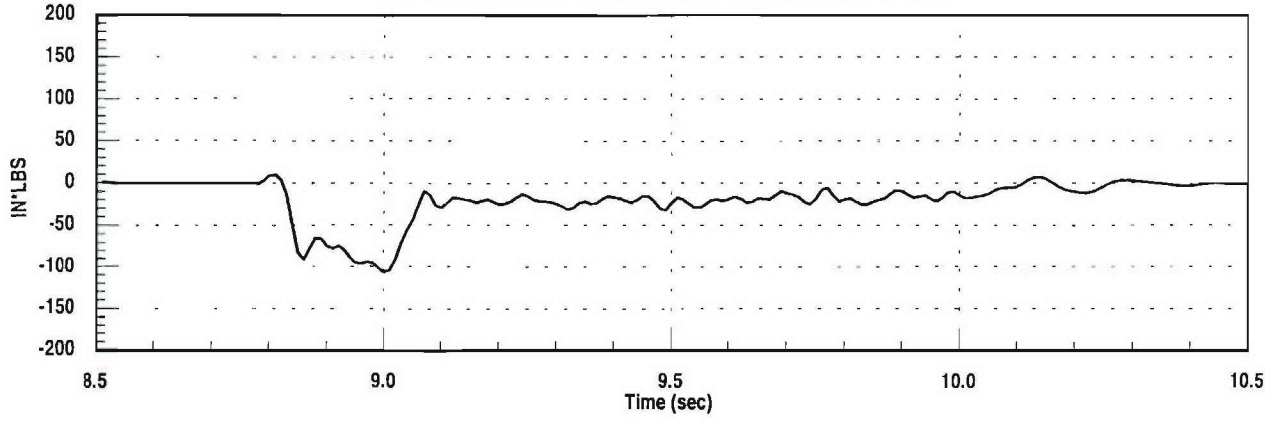
Neck Force Z



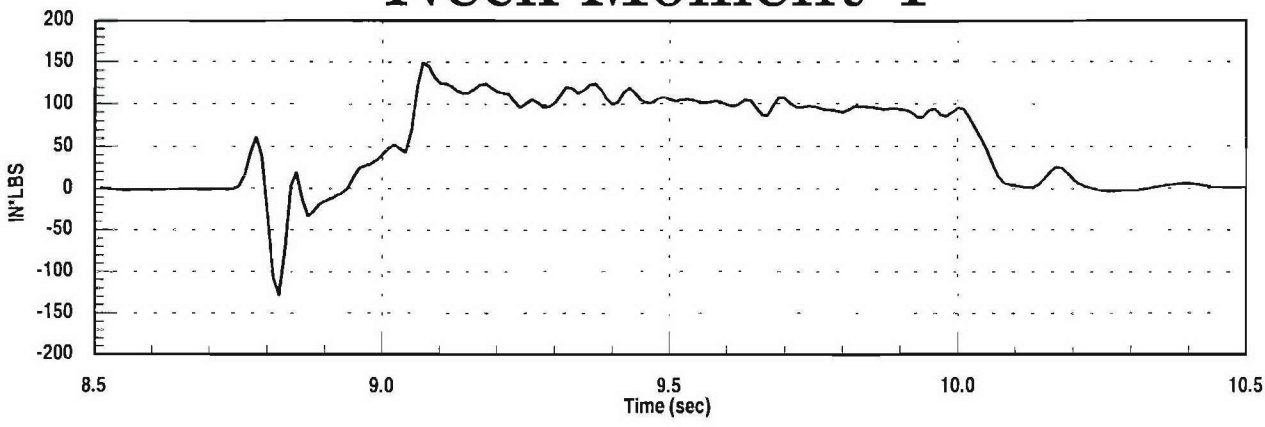
WD10, 575 KEAS

Post / Hybrid III

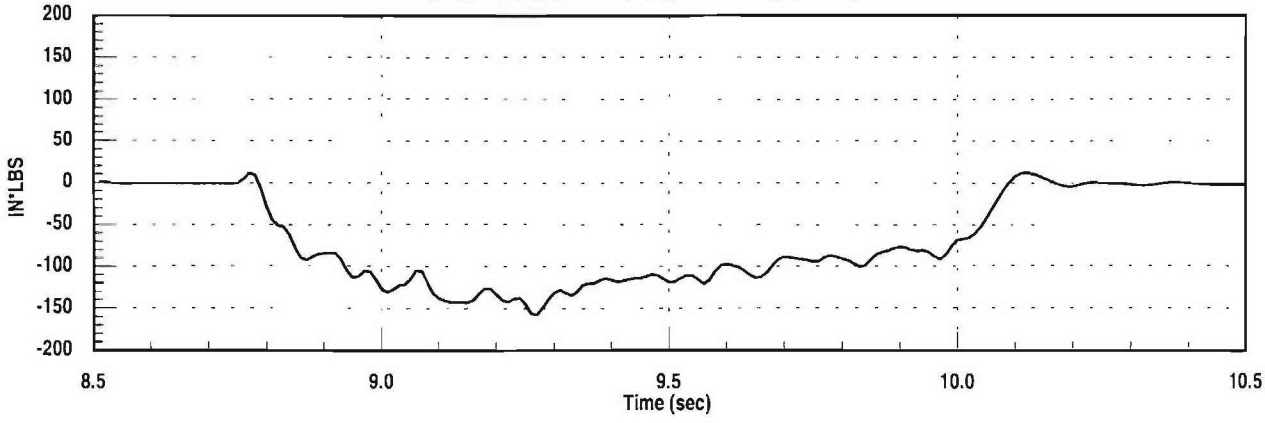
Neck Moment X



Neck Moment Y



Neck Moment Z



E-100

WD11, 575 KEAS

T-38 Baseline / Hybrid III

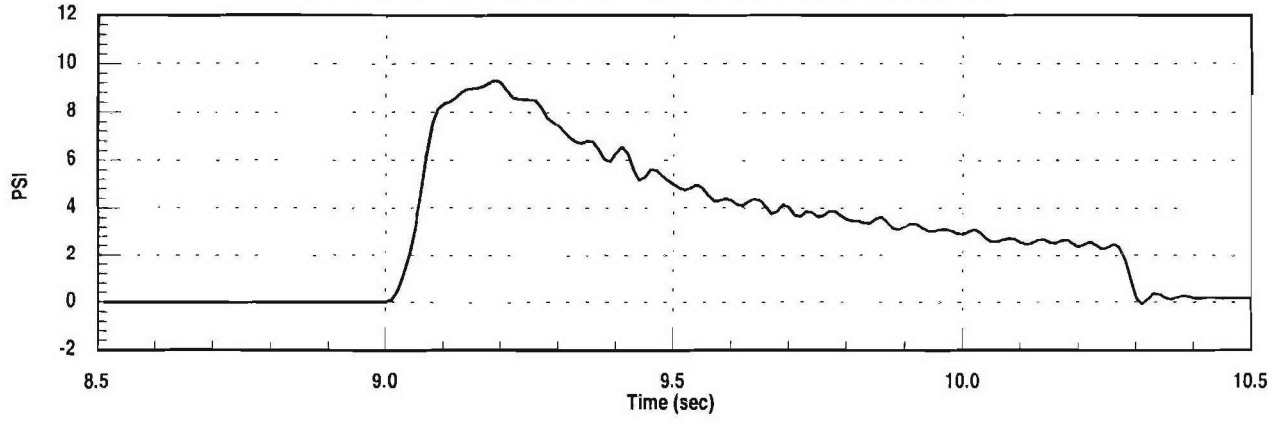
Processed Data

Main Rake Pressures	E-102
Neck Forces	E-103
Neck Moments	E-104

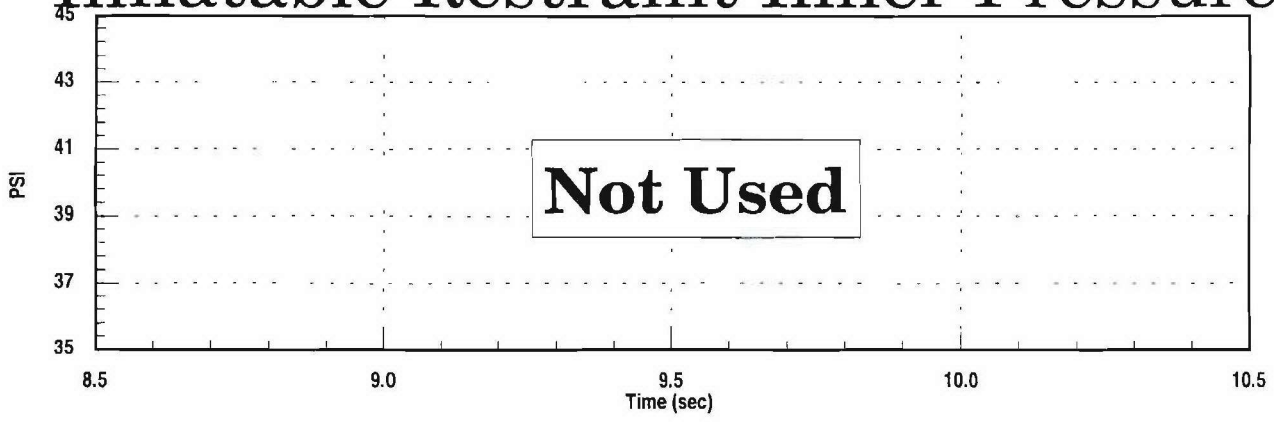
WD11, 575 KEAS

T-38 Baseline / Hybrid III

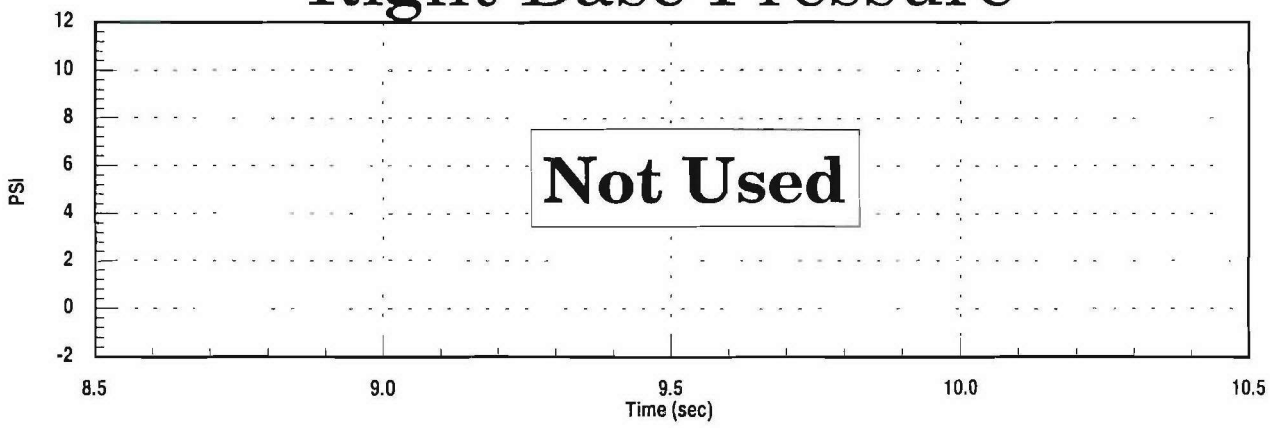
Main Rake Pressure



Inflatable Restraint Inner Pressure



Right Base Pressure

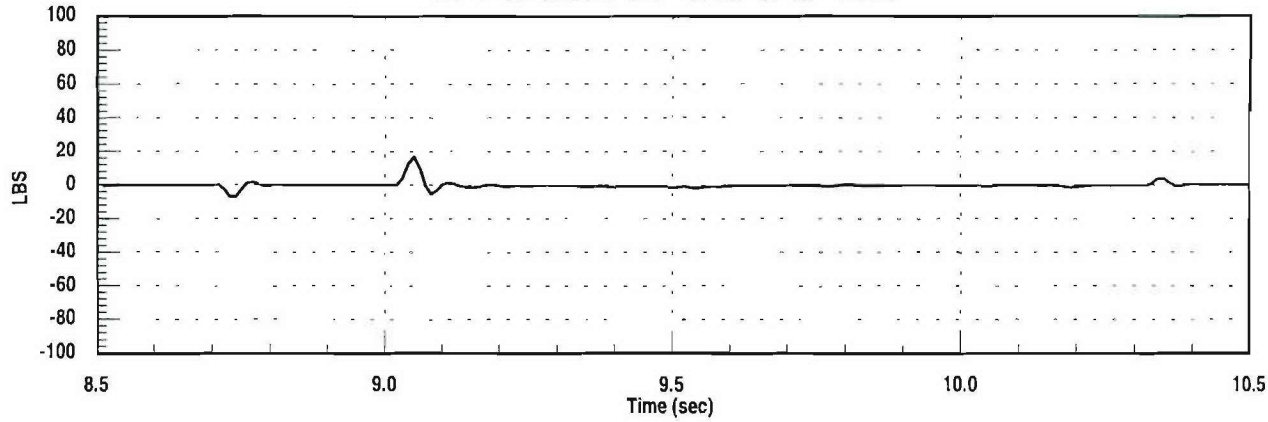


E-102

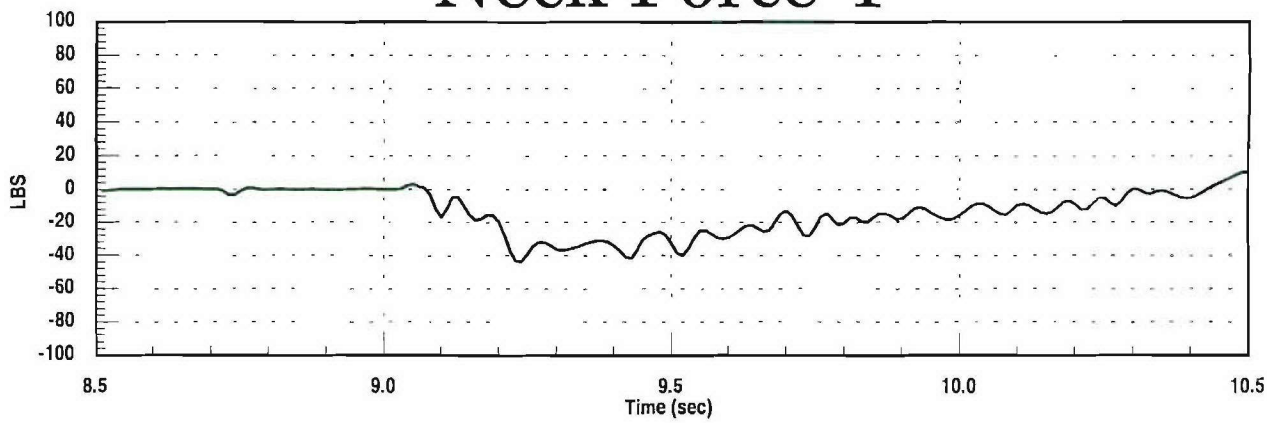
WD11, 575 KEAS

T-38 Baseline / Hybrid III

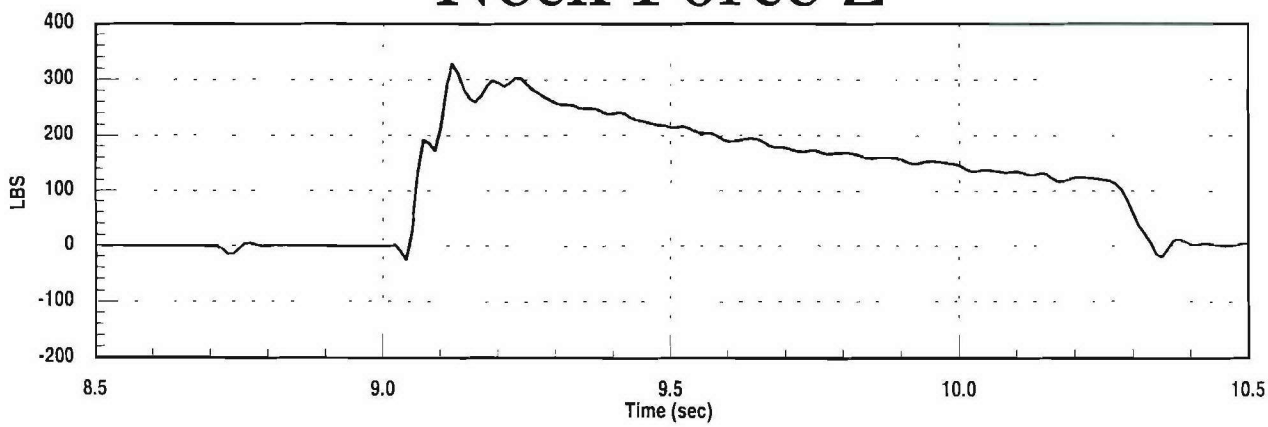
Neck Force X



Neck Force Y



Neck Force Z

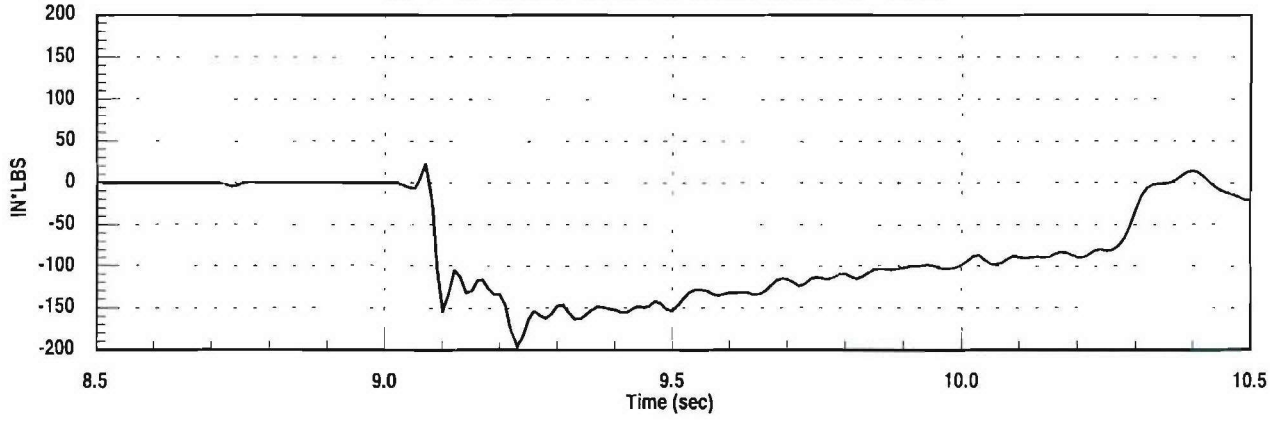


E-103

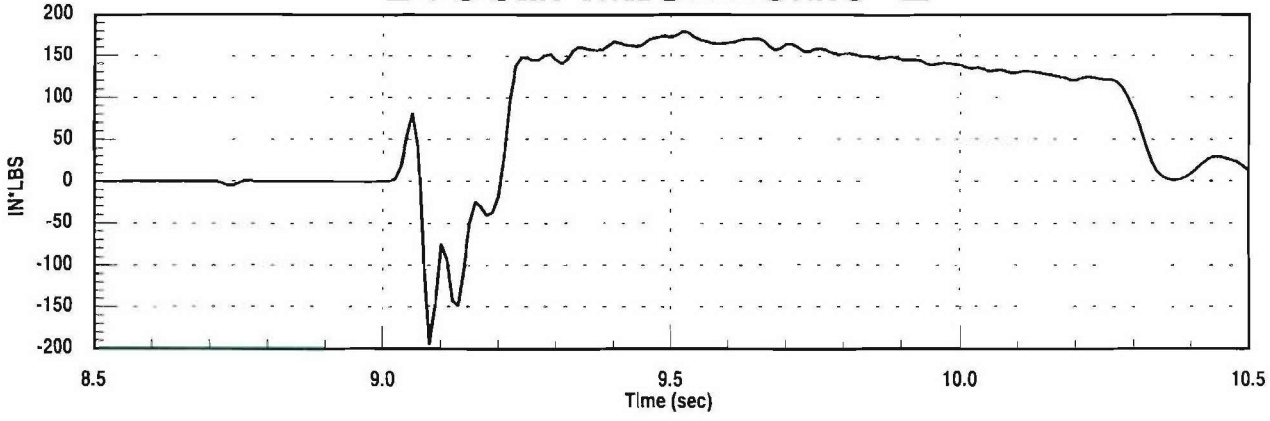
WD11, 575 KEAS

T-38 Baseline / Hybrid III

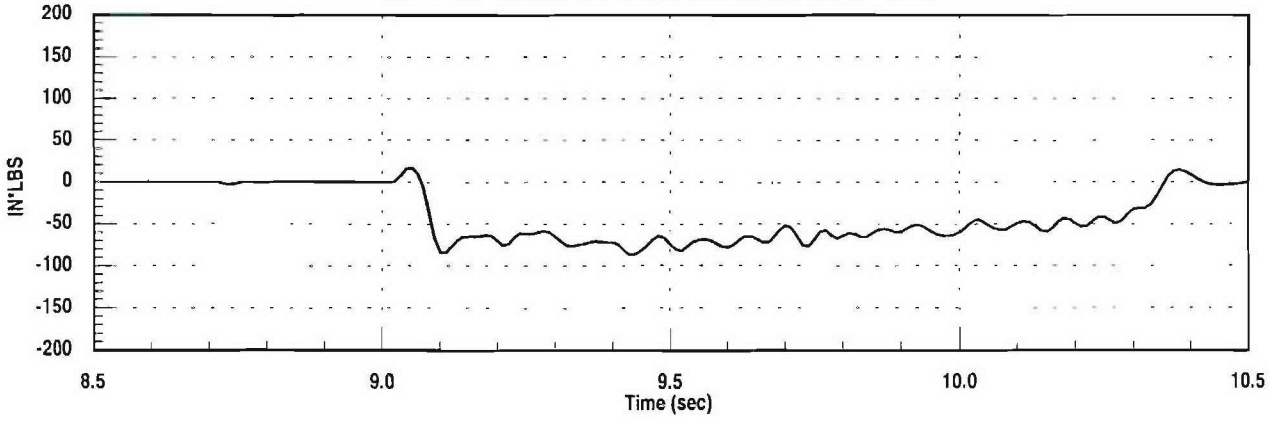
Neck Moment X



Neck Moment Y



Neck Moment Z



E-104

This page is intentionally left blank.

APPENDIX F

NECK LOAD SUMMARY

Test No.	Manikin	Windblast Deflector	Airspeed (KEAS)	Fx (lbs)		Fy (lbs)		Fz (lbs)		Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
1	Hybrid III	Baseline	350	34	-20	10	-22	123	-16	-46	-57	-101
1A	Hybrid III	Baseline	350	25	-19	8	-18	153	-2	-87	46	-102
9	Hybrid III	Pillar	575	14	-3	5	-25	170	-15	-73	83	-138
10	Hybrid III	Post	575	10	-2	7	-22	165	-16	-107	149	-157
11	Hybrid III	Baseline	575	17	-7	10	-44	330	-27	-198	-196	-87

Notes: Shaded areas are the Low Lift, Lightweight, and Low Cost Aviator's windblast tests. Non-shaded areas are from CREST's database.
* HGU-55/P without visor.

APPENDIX G

CHANNEL DEFINITION/CALIBRATION

Test: Inflatable Restraint Windblast
Helmet: HGU-55/P
Manikin: 50th Percentile Hybrid III
Velocity: 425-700 KEAS
Date: 24-28 April 2000

Mother Board	N/A
Power Board	
Memory Board	
Digital Board	
Analog - 1	
Analog - 2	
Analog - 3	
Analog - 4	

Channel	Event	Channel	Event
1		9	
2		10	
3		11	
4		12	
5		13	
6		14	
7		15	
8		16	

Channel	Ch. Symbol	Channel Description	Sensor	S/N	Units	Excitation	Sensitivity	Resistance	Range
1	NFX	Neck Force X	Denton 1716A	473	lbs	10 V	0.000783556	175	+/-2000
2	NFY	Neck Force Y	Denton 1716A	473	lbs	10 V	0.00080128275	175	+/-2000
3	NFZ	Neck Force Z	Denton 1716A	473	lbs	10 V	0.0003985781	350	+/-3000
4	NMX	Neck Moment X	Denton 1716A	473	in-lbs	10 V	0.0006690692	175	+/-2500
5	NMY	Neck Moment Y	Denton 1716A	473	in-lbs	10 V	0.0006692466	175	+/-2500
6	NMZ	Neck Moment Z	Denton 1716A	473	in-lbs	10 V	0.0009172724	350	+/-2500
7	MRP	Main Rake Pressure	XT-190-25G	5572-3-70	psi	10 V	0.3597	375	+/-15
8						10 V			
9	IRIP1	Inflatable Restraint Inner Pressure 1	XT-190-25G	5572-3-224	psi	10 V	0.3618	420	+/-15
10	IRIP2	Inflatable Restraint Inner Pressure 2	XT-190-25G	5572-3-226	psi	10 V	0.3622	355	+/-15
11	LBP	Lt Base Pressure	XT-190-25G	5572-3-229	psi	10 V	0.3655	347	+/-15
12	RBP	Rt Base Pressure	XT-190-25G	5941-1-114	psi	10 V	0.3503	778	+/-15
13	LA1	Left A1	XT-190-25G	5572-3-67	psi	10 V	0.3801	335	+/-15
14	LA2	Left A2	XT-190-25G	4073-4-128	psi	10 V	0.4074	234	+/-15
15	LB1	Left B1	XT-190-25G	5236-3A-94	psi	10 V	0.3630	704	+/-15
16	LB2	Left B2	XT-190-25G	4073-4-131	psi	10 V	0.4067	234	+/-15
17	LC1	Left C1	XT-190-25G	5236-3A-95	psi	10 V	0.3759	705	+/-15
18	LC2	Left C2	XT-190-25G	5236-3A-119	psi	10 V	0.4474	234	+/-15
19	LD1	Left D1	XT-190-25G	4073-4-134	psi	10 V	0.4607	236	+/-15
20	LD2	Left D2	XT-190-25G	5572-3-68	psi	10 V	0.3763	400	+/-15
21	LE1	Left E1	XT-190-25G	5572-3-59	psi	10 V	0.3581	405	+/-15
22	LE2	Left E2	XT-190-25G	4073-4-137	psi	10 V	0.4898	266	+/-15
23	RA1	Right A1	XT-190-25G	5350-6-255	psi	10 V	0.3989	461	+/-15
24	RA2	Right A2	XT-190-25G	4073-4-139	psi	10 V	0.4385	228	+/-15
25	RB1	Right B1	XT-190-25G	5350-6-254	psi	10 V	0.3749	535	+/-15
26	RB2	Right B2	XT-190-25G	4073-4-142	psi	10 V	0.4670	232	+/-15

27	RC1	Right C1	XT-190-25G	4073-4-144	psi	10 V	0.3964	236	+/-15
28	RC2	Right C2	XT-190-25G	5236-3A-93	psi	10 V	0.3509	760	+/-15
29	RD1	Right D1	XT-190-25G		psi	10 V			+/-15
30	RD2	Right D2	XT-190-25G		psi	10 V			+/-15
31	RE1	Right E1	XT-190-25G		psi	10 V			+/-15
32	RE2	Right E2	XT-190-25G		psi	10 V			+/-15

This page is intentionally left blank.

APPENDIX H

TEKSCAN TESTS

The injury criteria for chest compression loading are the Maximum Chest Compression and the Viscous Criterion calculated from a string pot attached to the manikin chest. The current manikin used for ejection testing is not capable of making this measurement due to the incorporation of an on-board Data Acquisition System (DAS). Existing testing procedures do not provide a means to measure the aerodynamic pressure exerted on the manikin chest during ejection. With increasing aircraft cruise velocity, the likelihood of higher average ejection speed will require this testing capability to ensure that injury risk assessment is complete and accurate. It is also important to investigate chest compression in order to determine restraint system performance. During ejection, the chest can be loaded from either the tightening of the restraint system or impact with cockpit structures. The loading from the harness can be due to the inertial loading by the occupant or to the addition of a pretensioner or hypertensioner of the belt. Other possible causes of an impact to the chest include interaction with inflatable structures, landing fall, or cockpit clearance.

Tekscan Company has recently developed a sensor mat that can be used to collect pressure data. Tests were conducted at Dayton T. Brown, Long Island, NY, to study the possibility of using this device for measurement of chest loading during windblast exposure. If successful, this testing method can be used to estimate chest compression loads and airflow distribution on the manikin during sled ejection tests. This measurement technology could then be expanded to the measurement of loads on other areas of the manikin including the top of the head for measurement of pressure differential between the head and helmet, the limbs, and the front of the head.

Figure H-1. Kulite Sensor

Two tests were conducted at 375 KEAS to determine the Tekscan sensor mat's suitability for use in an ejection environment. The first test was conducted with a Kulite sensor array to provide baseline data (Figure H-1). The second test was performed with the Tekscan sensor mat being affixed to a flat plate (Figure H-2). Due to the variation in frontal geometry between the Kulite sensor array and the Tekscan sensor mat, direct comparison could not be made. The aerodynamic shape of the flat plate, while better representing the manikin chest area, caused more flow turbulence as seen in Appendix I.

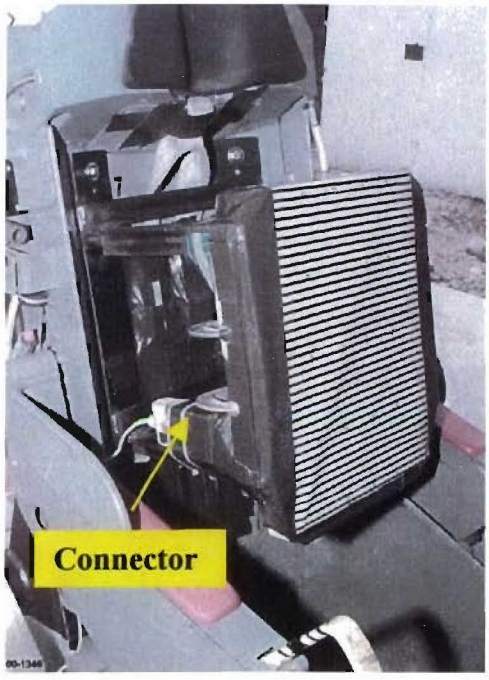


Figure H-2. Tekscan Sensor

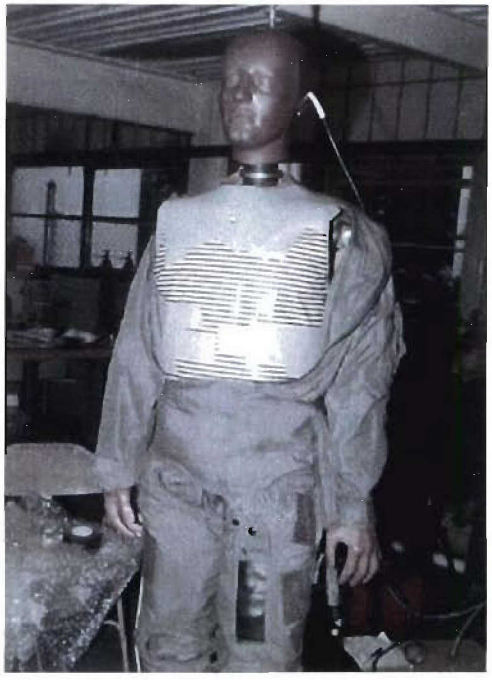


Figure H-3. Manikin with Sensor Mat

Two tests were conducted at 350 KEAS (Tests 1 and 1A, Appendix D) with the sensor mat affixed to the manikin's torso skin under the flight suit (Figure H-3). The purpose of these tests was to measure the airflow pressure exerted on the manikin's upper body. The Tekscan connector became unplugged in both tests, resulting in no data being recorded. Attempts to secure this connection were unsuccessful due to the connector design mechanism. Until this connectivity problem is resolved, the Tekscan is deemed unsuitable for use in a high stress or high vibration environment.

This page is intentionally left blank.

APPENDIX I

TEKSCAN AND KULITE SENSOR ARRAY DATA PLOTS

Calibration, 375 KEAS

Tekscan / Torso Rake

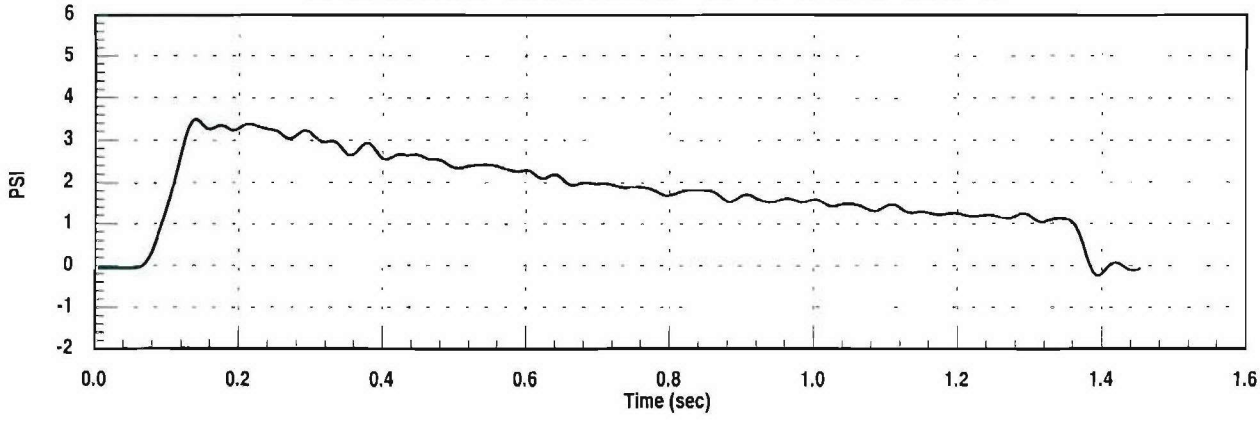
Processed Data

Main Rake Pressure	I-2
Row 1 Sensor 1 & 2 Pressures	I-3
Row 1 Sensor 3 & 4 Pressures	I-4
Row 2 Sensor 1 & 2 Pressures	I-5
Row 2 Sensor 3 & 4 Pressures	I-6
Row 3 Sensor 1 & 2 Pressures	I-7
Row 3 Sensor 3 & 4 Pressures	I-8
Row 4 Sensor 1 & 2 Pressures	I-9
Row 4 Sensor 3 & 4 Pressures	I-10
Row 5 Sensor 1 & 2 Pressures	I-11
Row 5 Sensor 3 & 4 Pressures	I-12

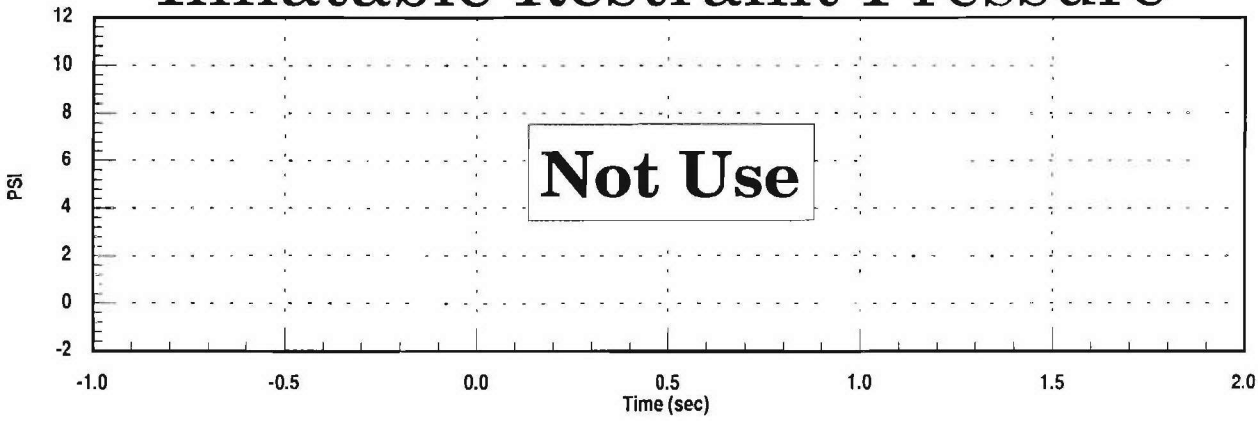
Calibration, 375 KEAS

Tekscan / Torso Rake

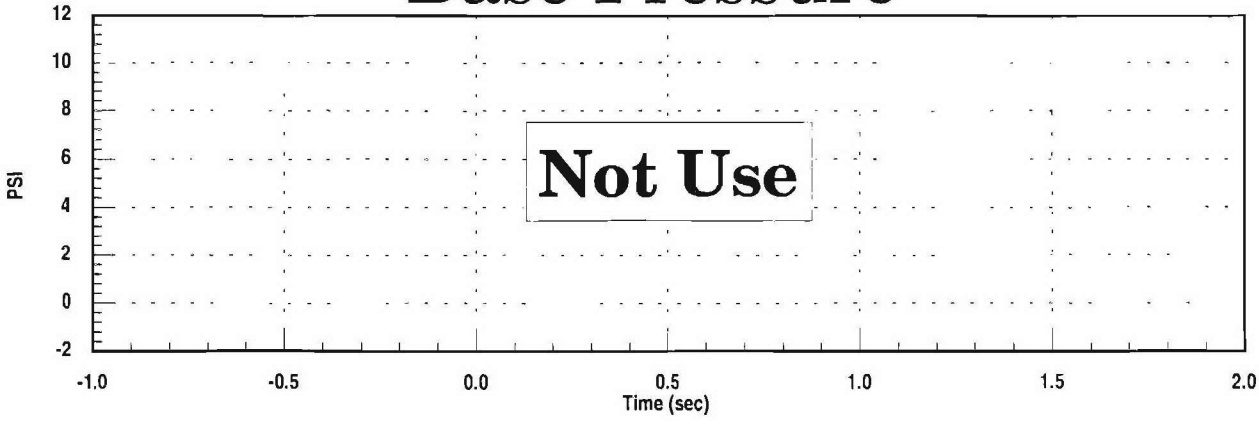
Main Rake Pressure



Inflatable Restraint Pressure



Base Pressure

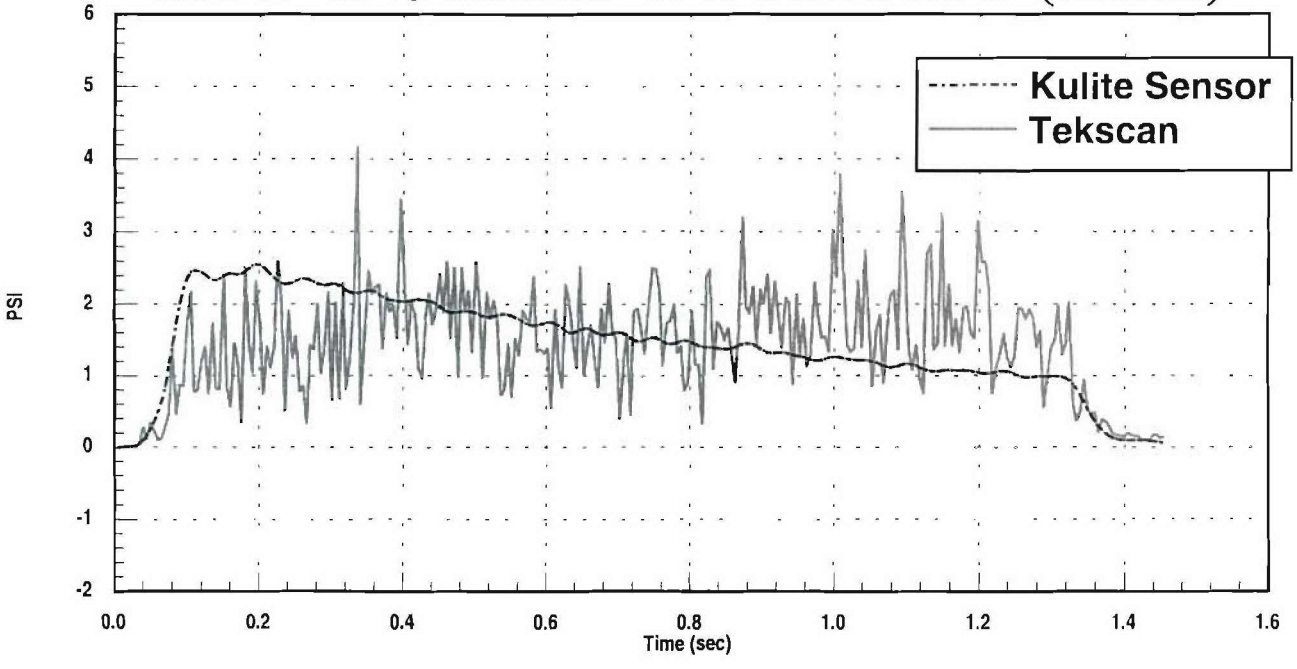


I-2

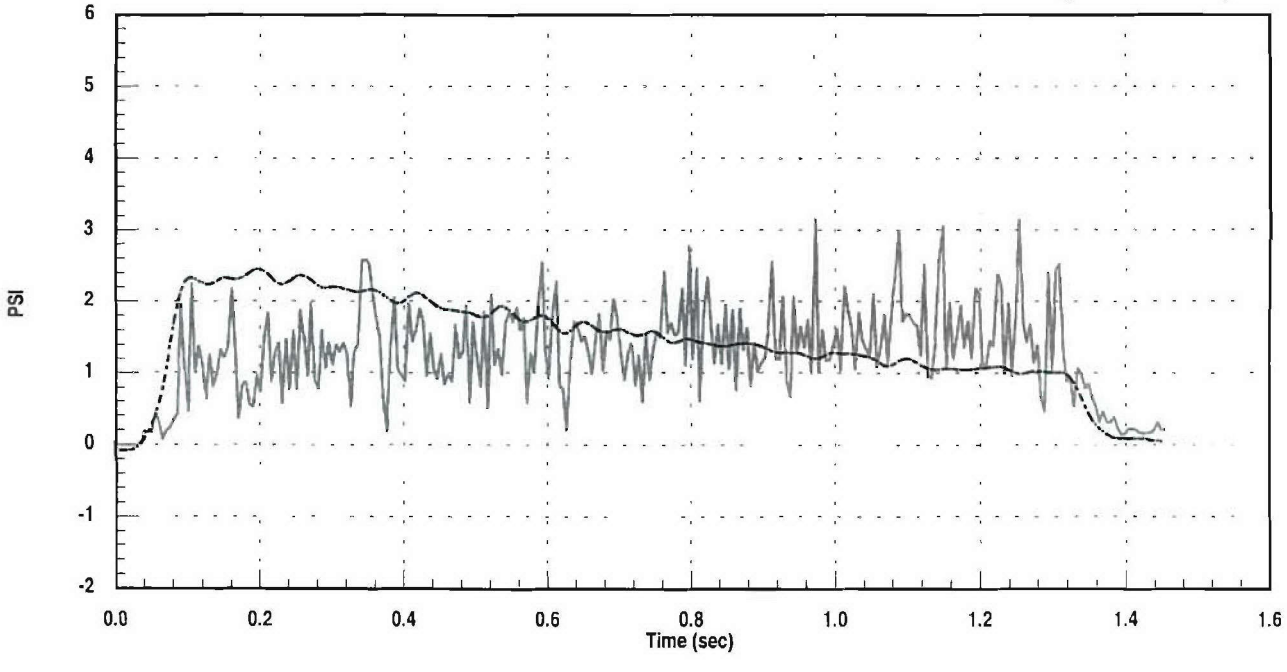
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 1 Sensor 1 Pressure (LA1)



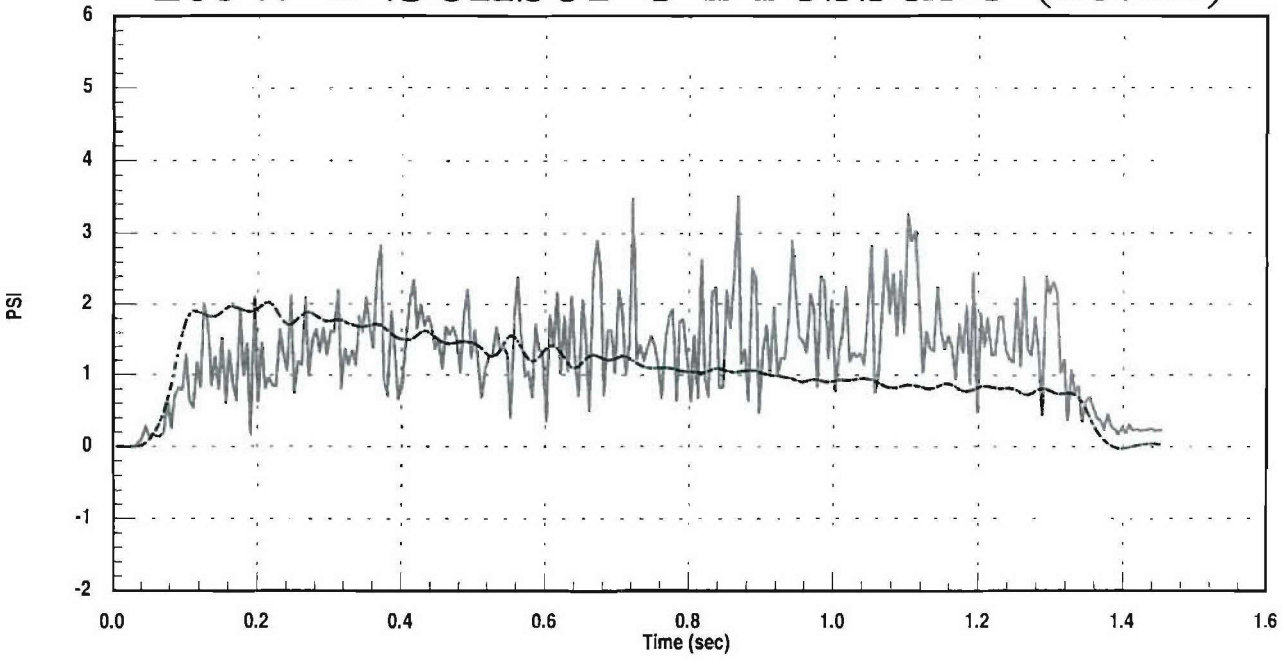
Row 1 Sensor 2 Pressure (LA2)



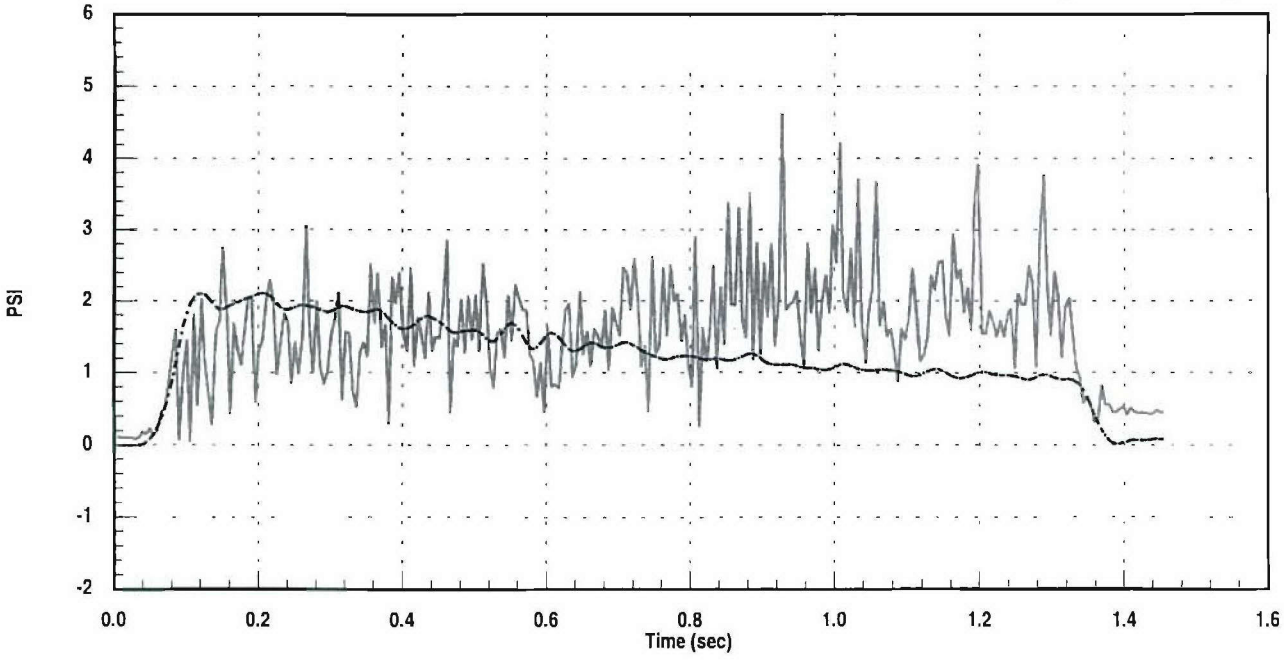
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 1 Sensor 3 Pressure (RA2)



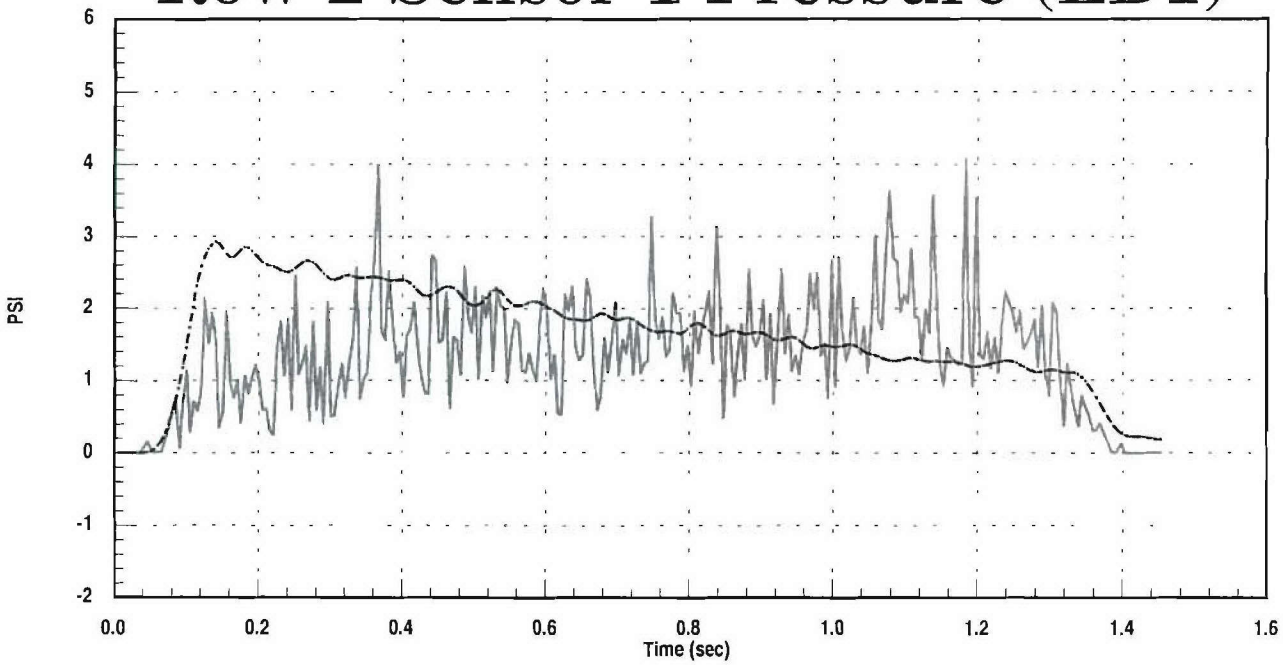
Row 1 Sensor 4 Pressure (RA1)



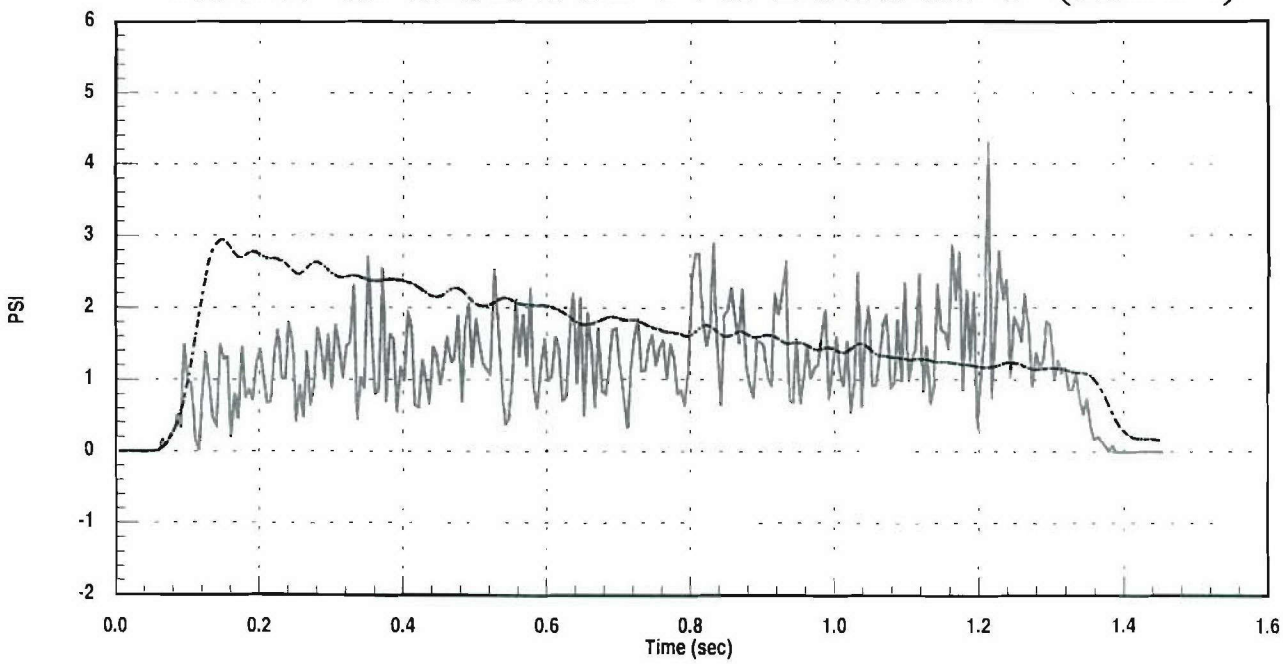
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 2 Sensor 1 Pressure (LB1)



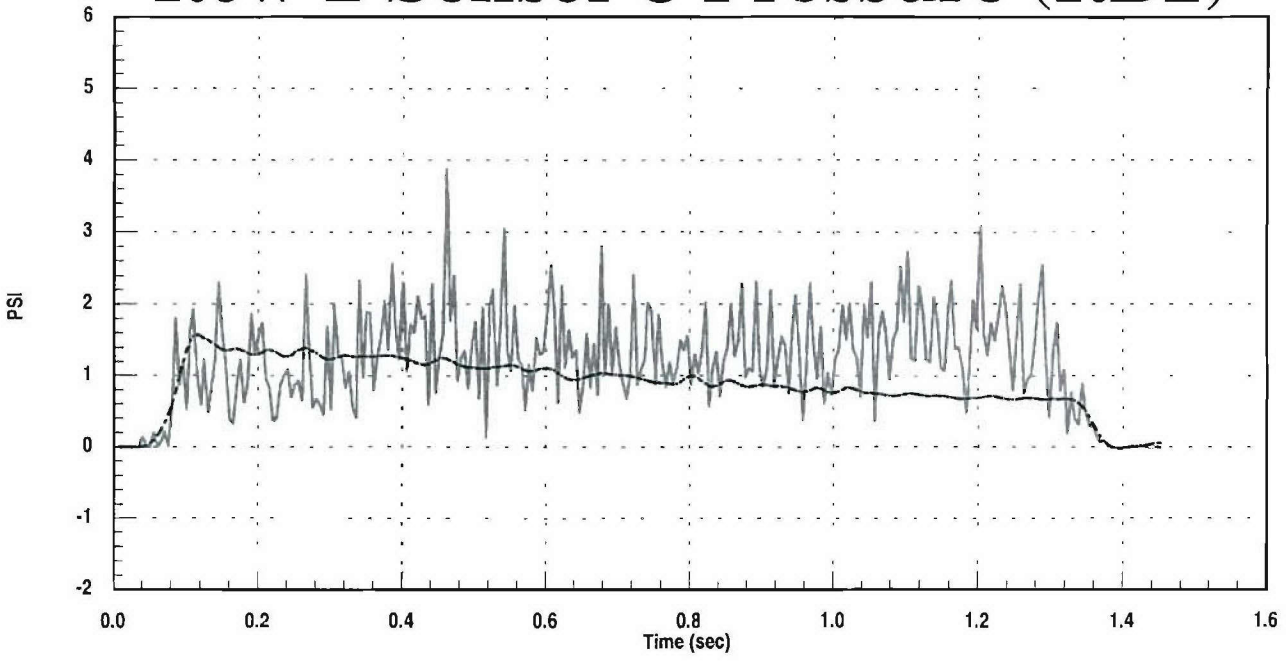
Row 2 Sensor 2 Pressure (LB2)



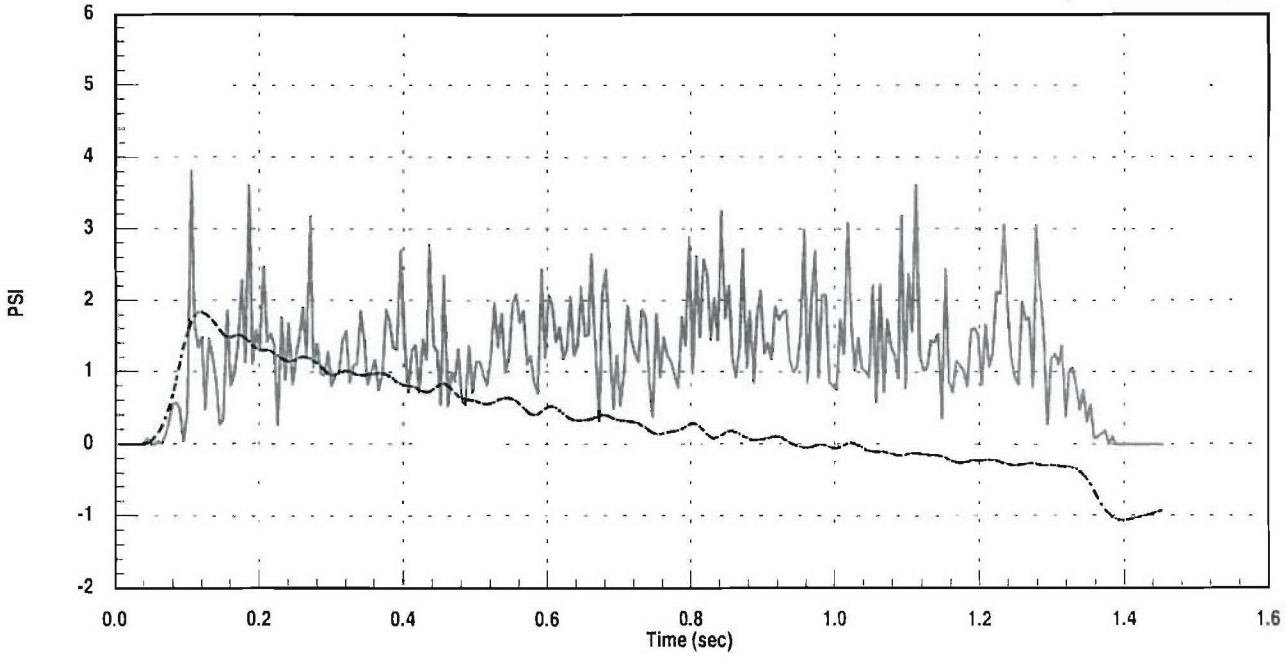
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 2 Sensor 3 Pressure (RB2)



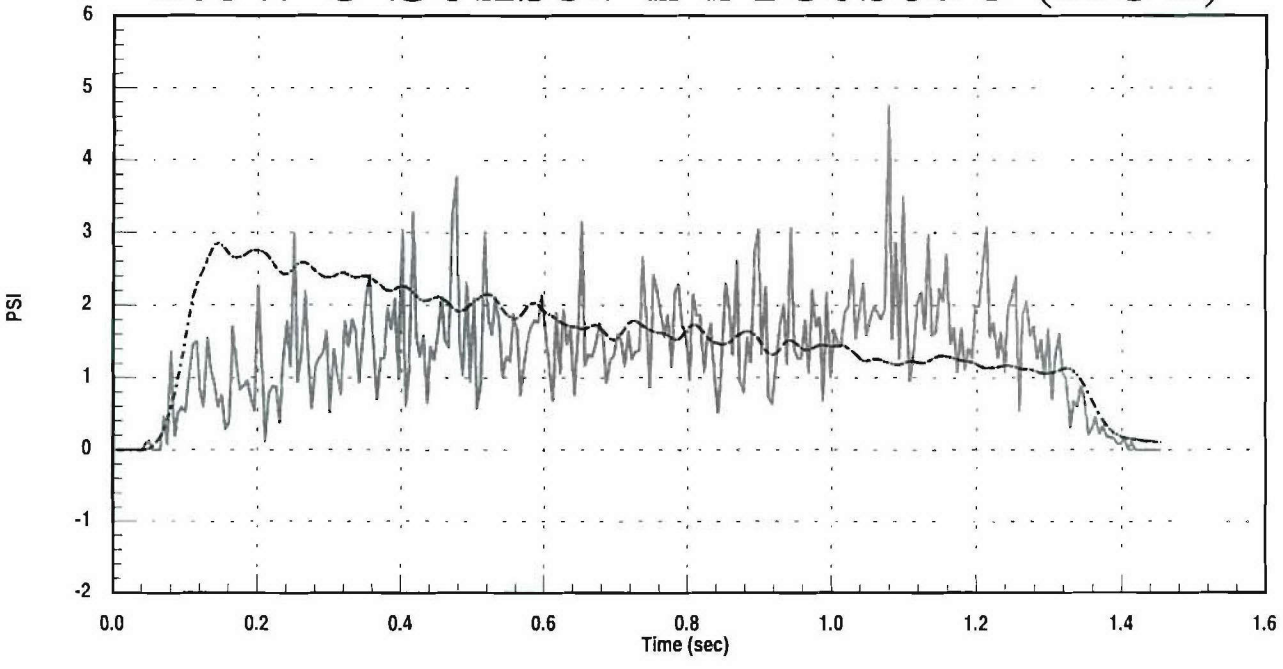
Row 2 Sensor 4 Pressure (RB1)



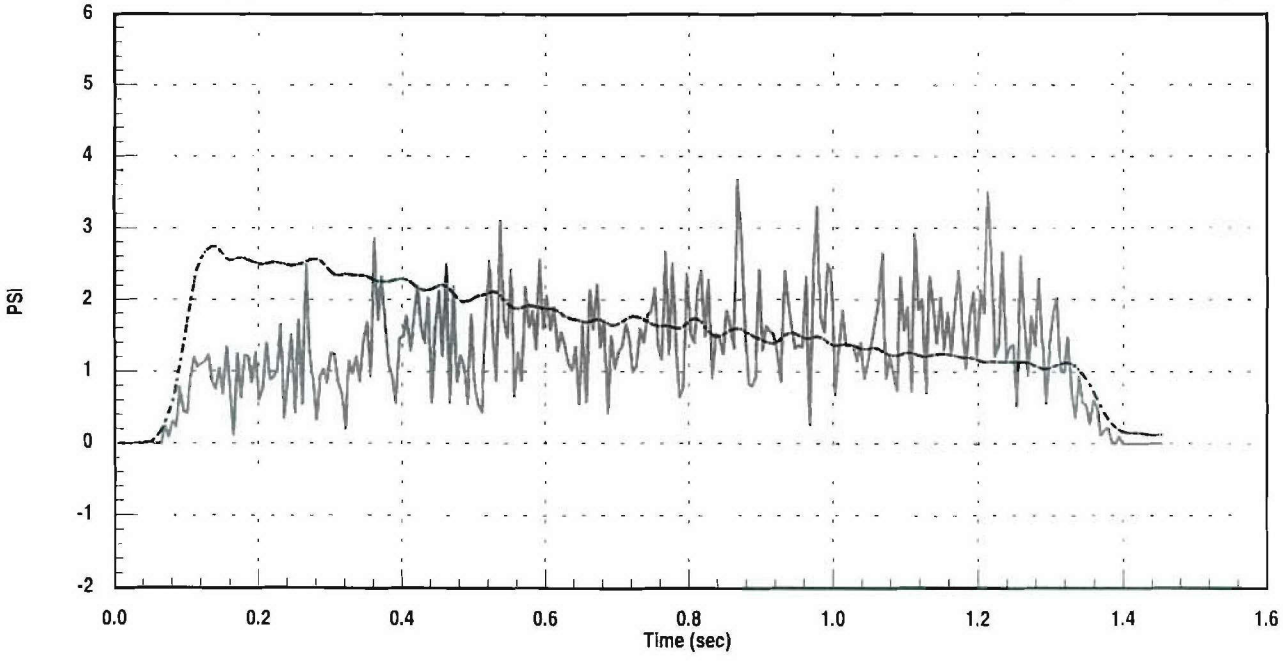
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 3 Sensor 1 Pressure (LC1)



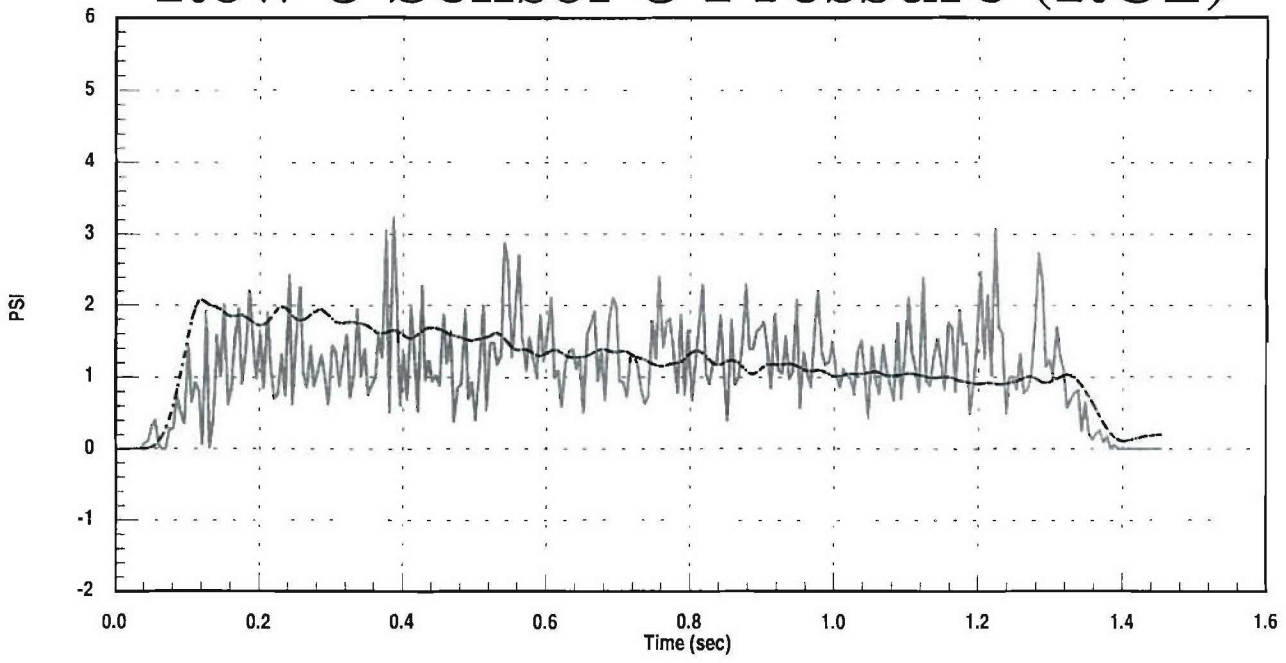
Row 3 Sensor 2 Pressure (LC2)



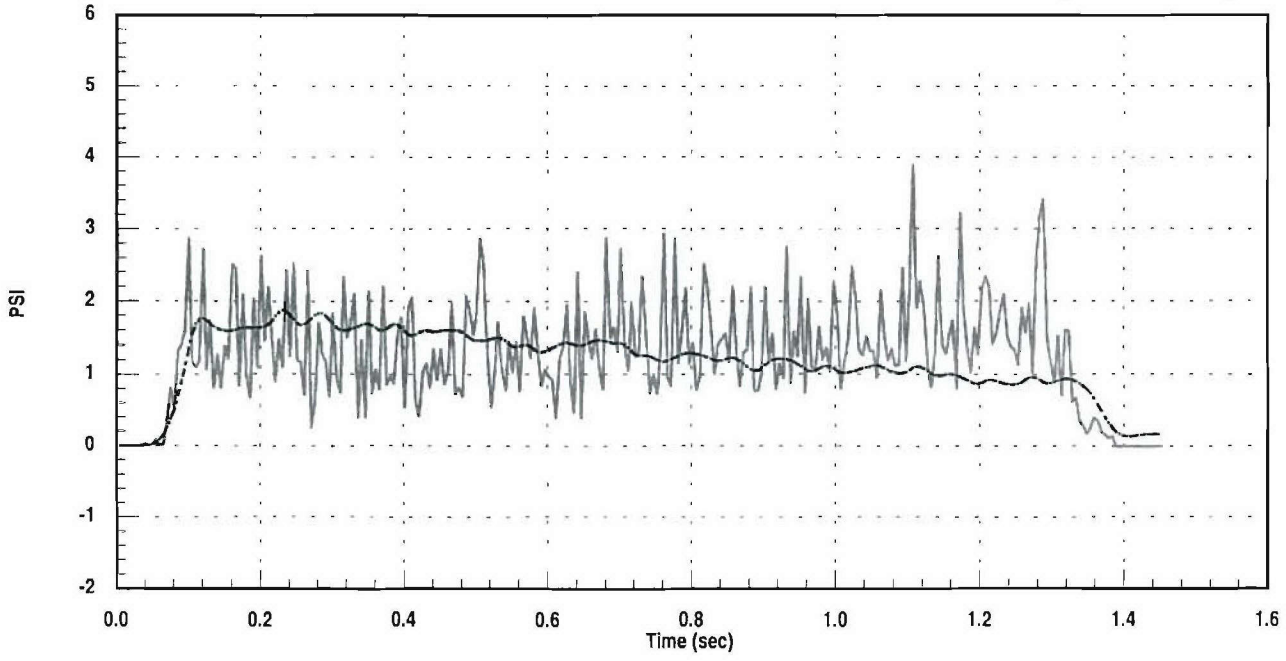
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 3 Sensor 3 Pressure (RC2)



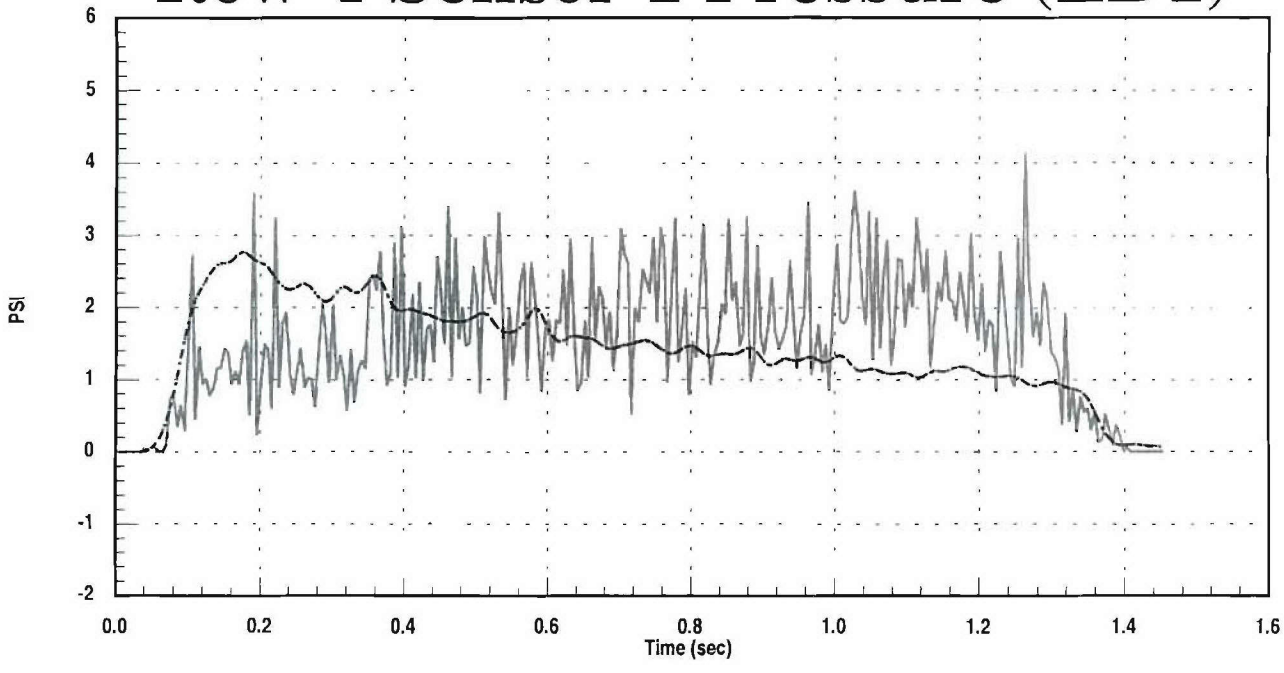
Row 3 Sensor 4 Pressure (RC1)



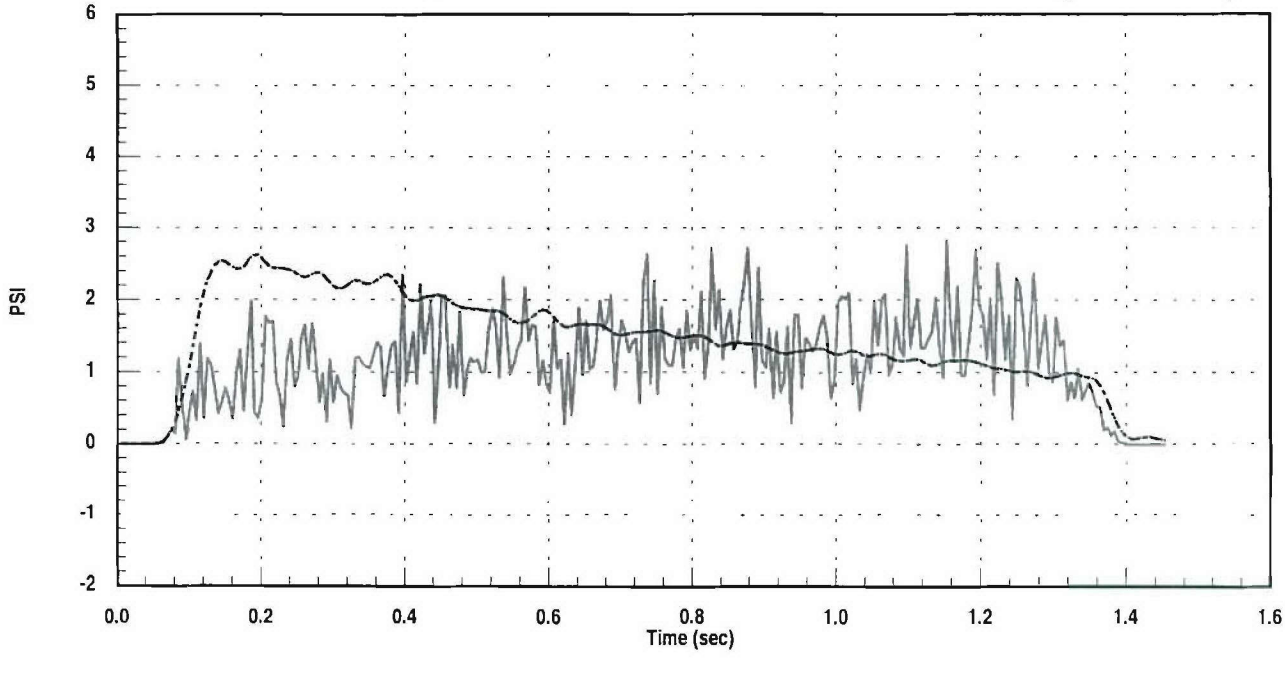
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 4 Sensor 1 Pressure (LD1)



Row 4 Sensor 2 Pressure (LD2)

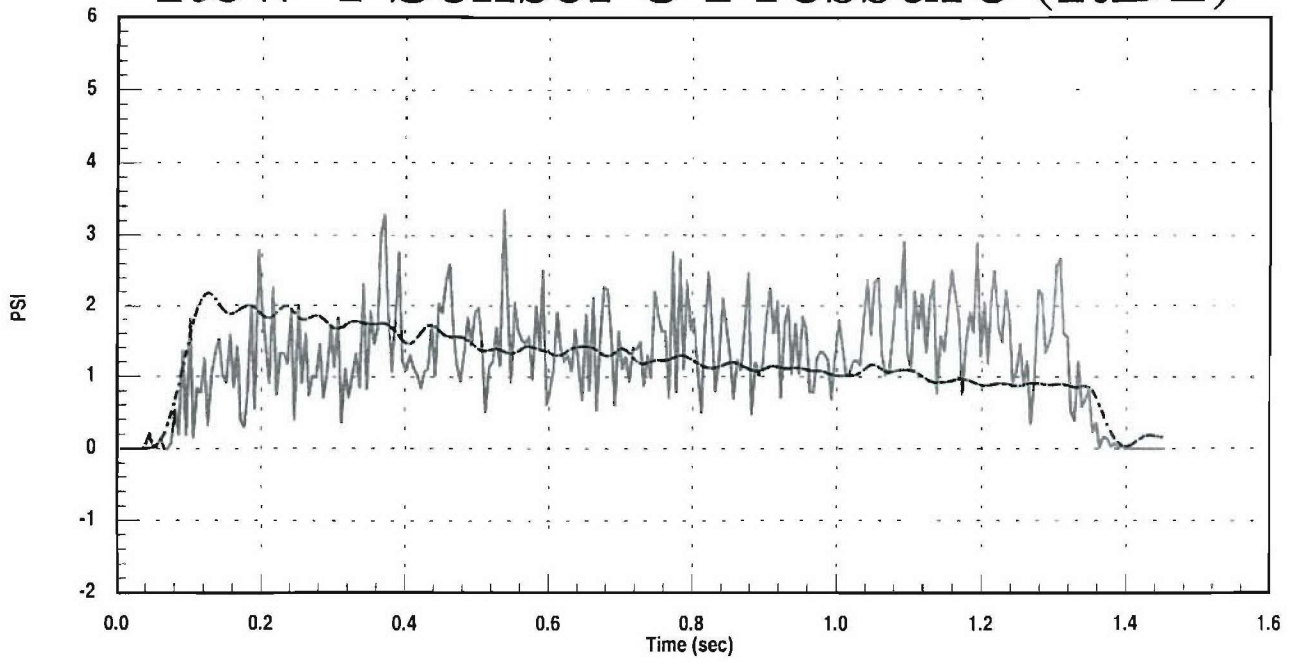


I-9

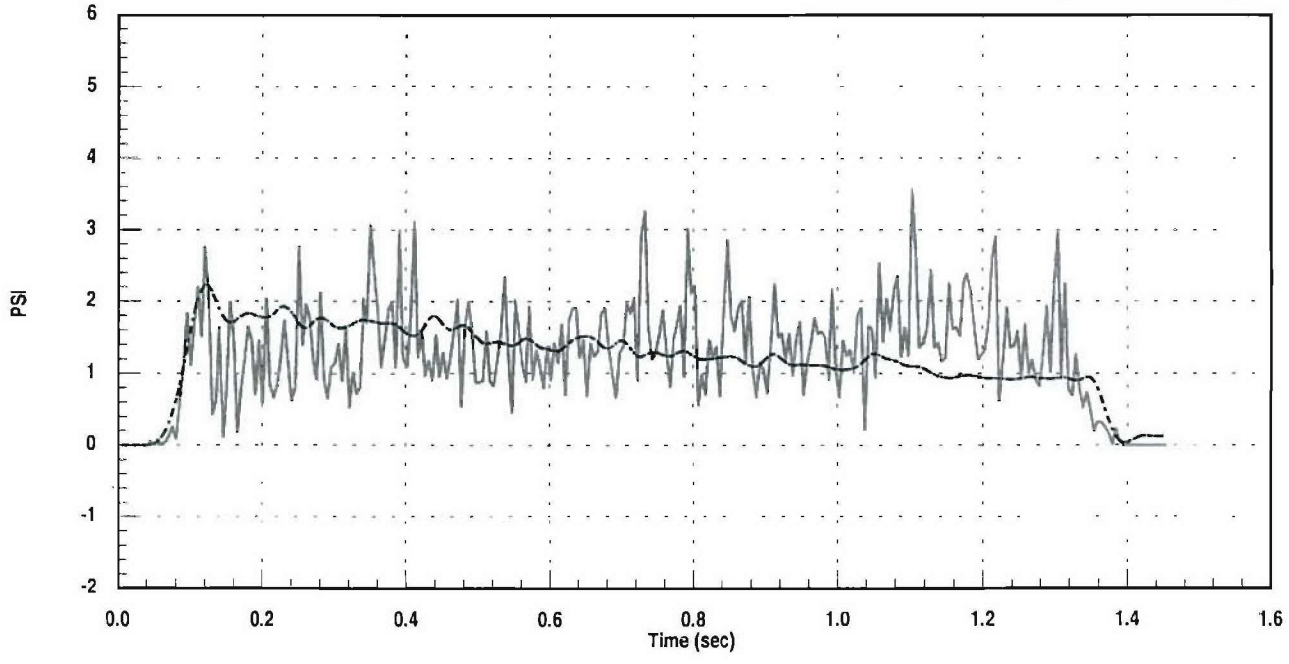
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 4 Sensor 3 Pressure (RD2)



Row 4 Sensor 4 Pressure (RD1)

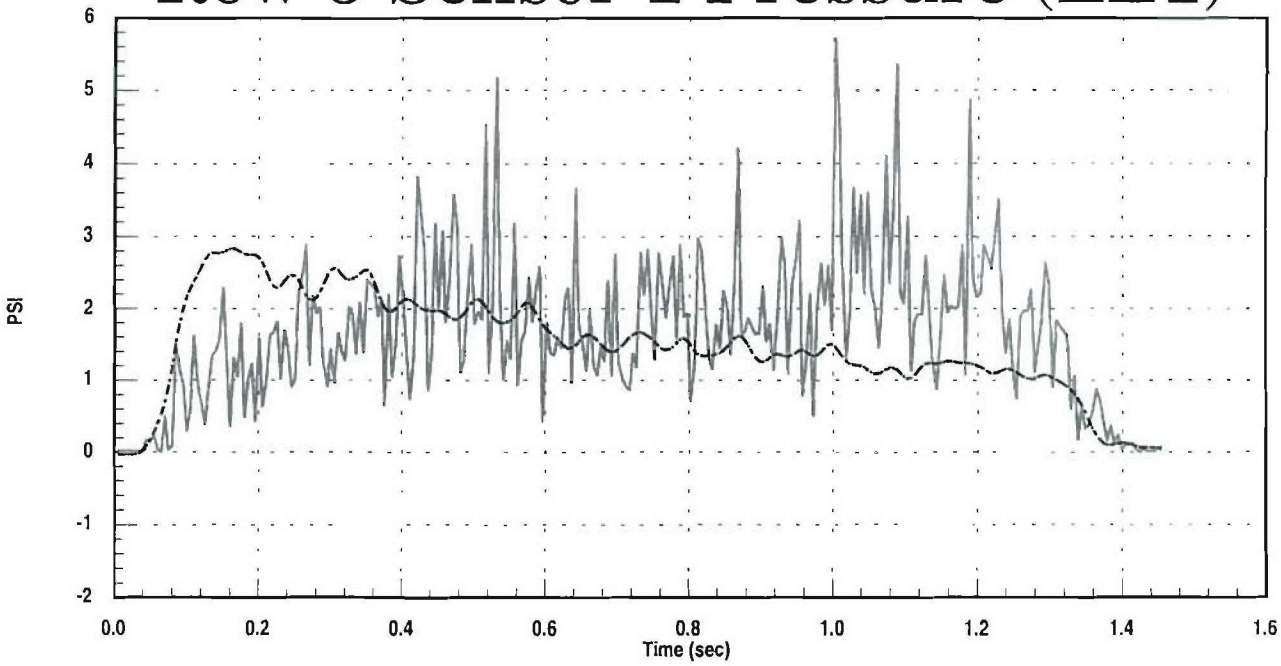


I-10

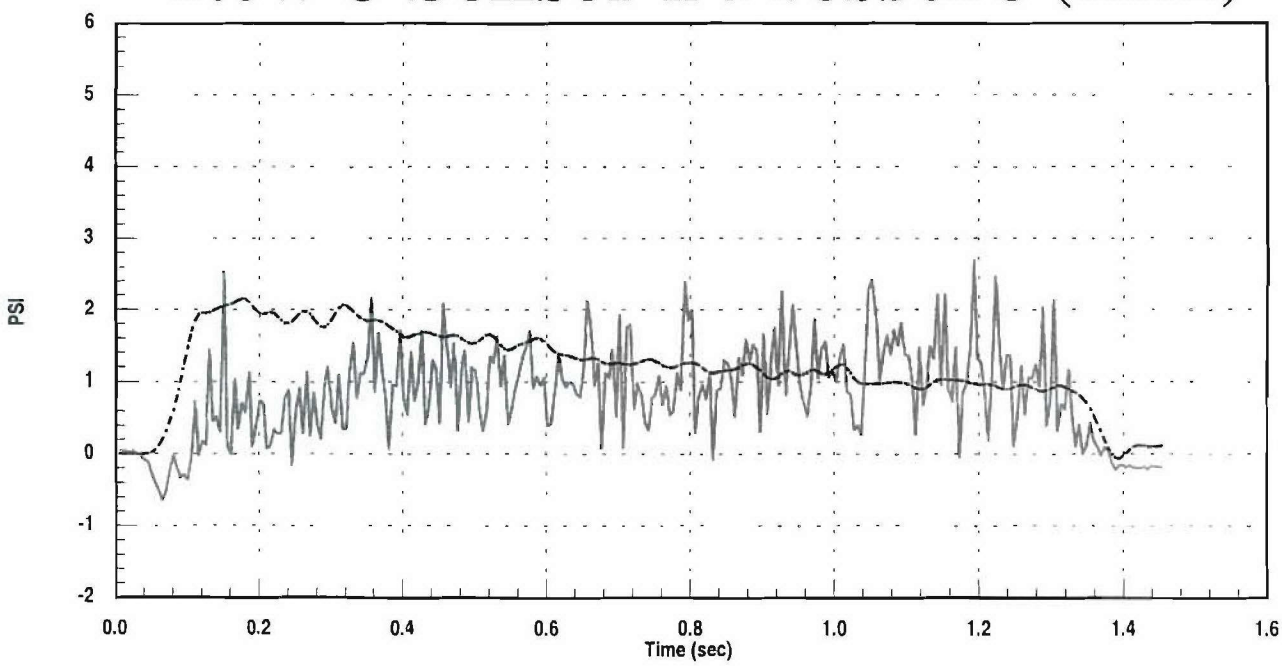
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 5 Sensor 1 Pressure (LE1)



Row 5 Sensor 2 Pressure (LE2)

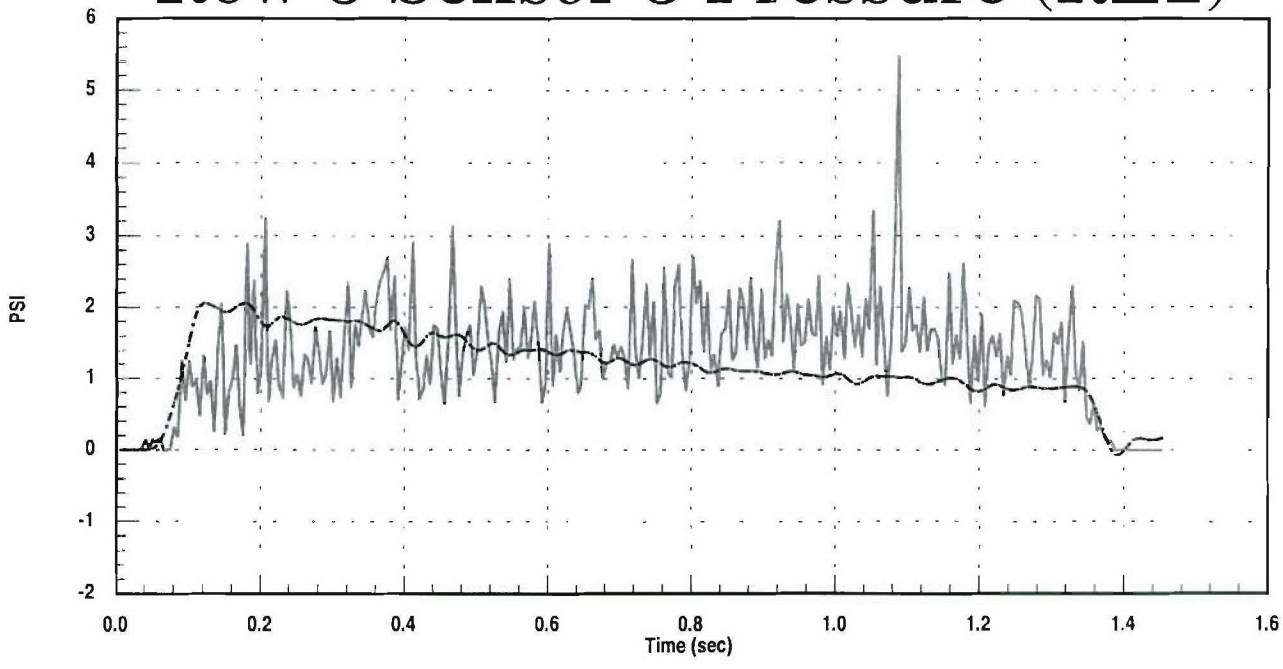


I-11

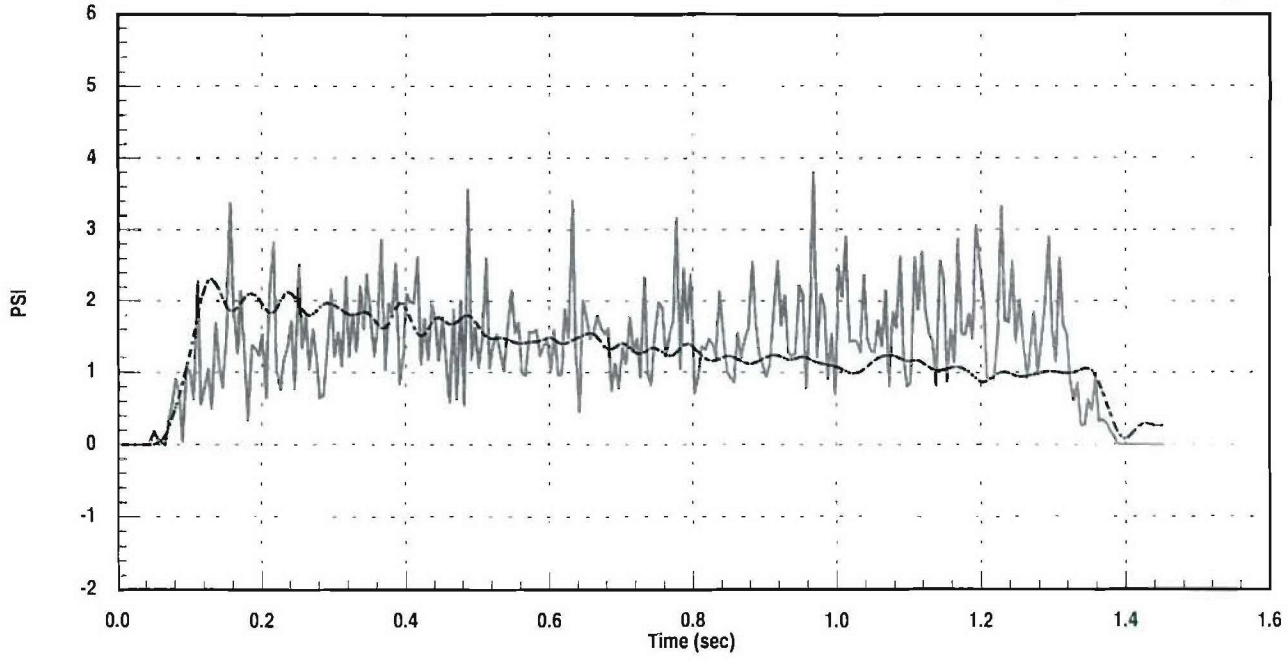
Calibration, 375 KEAS

Tekscan / Torso Rake

Row 5 Sensor 3 Pressure (RE2)



Row 5 Sensor 4 Pressure (RE1)



I-12